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THE NETWORK-BASED APPROACH TO CURRICULUM DEVELOPMENT FOR VOCATIONAL PROGRAMS

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "The Network-Based Approach to Curriculum Development for Vocational Programs," submitted by Warren Elkanah Hathaway in partial fulfilment of the requirements for the degree of Master of Education.

ABSTRACT

Demands are being placed on educators to develop educational programs for a growing number of students destined to remain in school for increasing periods of time. Many of the programs focus on vocational education. Inseparable from the influx of students is an increase in the range of individual differences encountered. This factor necessitates consideration of the individual learner in curriculum development. On the other hand, few approaches to curriculum development provide adequate technology suited to either construction of a curriculum for individualized instruction or integration of the fragments of instruction presented by several departments into a meaningful program. It is into these areas that this study enters.

Following a review of curriculum development literature a model is structured to focus attention on key relationships to be considered in a viable approach to curriculum development. Network planning is evaluated in terms of its effectiveness in meeting constraints imposed by elements of the curriculum development model. This is followed by amplification of the approach to curriculum development for vocational education to include means for; selecting and organizing curriculum content, integrating subject curricula into a program curriculum, and facilitating administrative considerations such as schedules and student programming. A number of curriculum implementation

methods are discussed both from a theoretical standpoint and on the basis of results obtained from an investigation into individualized instruction.

The entire approach to curriculum development is subjected to an evaluation in terms appropriate to any curriculum project. Based on the positive indications extracted from the evaluation, as well as data gathered during the initial classroom investigations into individualized instruction, a management plan is presented to facilitate application of the approach in various settings.

Results of the study indicate that the approach facilitates; curriculum content selection and organization, concurrent subject integration, sequential subject integration, and administrative factors involved in deriving a meaningful single vocational program curriculum that can be implemented through team teaching or individualized instruction.

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INTRODUCTION

Rationale for the Study

The educational scene is made conspicuous by the increasing number of programs introduced at the senior high school level. Frequently these are vocational education programs which focus on preparation of youth for entrance into the world of work, while concurrently satisfying needs stemming from the individual differences posed by the gifted, the handicapped, and the under-achiever. Needs, in this context, are interpreted to mean disparities between the learner's present behavior and the terminal behavior specified by the curriculum (Taba, 1962, p. 286).

One such program, vocational education for the culturally disadvantaged, was studied by Frazier (1966). His conclusion indicates that programs combining skill training classes with academic classes have a greater impact on overall achievement and social adjustment than skill training or academic studies undertaken separately.

Following a review of recent research, Scriven (1967, p. 6) arrives at much the same conclusion. She reports that learning is acquired more easily and retained longer if the material is fitted into a structure that the student can find meaningful.

Since the curriculum is not meaningful to all of the

students it may be useful to delve into our recent history to observe trends which may account for the lack of meaning or relevancy in contemporary educational programs.

The skilled craftsman who expertly fashioned products from basic materials has been replaced by automated systems capable of mass producing comparable products through sequences of independent operations. This form of production often leaves workers with an inadequate understanding of their role in the total production cycle. Part of the risk of assembly-line production may be reckoned in terms of the anxiety and frustration induced in workers because they do not understand how they, as cogs, fit into the gears of industry (Brown 1954, pp. 281-282).

Education has undergone a similar transition over the years. Gone are the rural classrooms presided over by schoolmarms--education's counterparts of the skilled craftsmen. Though the adequacy of education in those remote rural settings may be criticized, certain facets are deserving of comment.

Rural teachers directed the learning experiences of children in several grades by following curriculum plans that remained flexible in their minds. Equipped with cognitive maps of the curriculum, each teacher attended to the sequential nature of each subject, the interactive relationships of the various subjects, and the impact of the total on the students. Arithmetic did not have to stop when geography started, nor did geography have to stop to

make way for reading, art, or history. The teacher was free to select learning experiences from several areas to reinforce concepts that proved difficult to master in one area. Within the rural school the potential existed for a truly integrated curriculum with students progressing as rapidly as they were able. Those students who required special assistance received it from either the teacher or an older student who had already demonstrated mastery of the subject. Observations by the teacher of the assimilation of the graduates into the immediate segment of productive society, enabled further modifications to the program for the benefit of future graduates. The nongraded classrooms advocated by some today, were a reality not too long ago (Goodlad and Anderson 1959, pp. 52-53).

In the same way that the teacher understood the entire program, the students also knew the purpose and direction of their education. They learned their role and the expectations held of them. Upon entering the first grade, students had several years to learn the role required of them prior to advancing across the room to sit by the window in a seat occupied only by seniors.

Centralization has now almost completely eliminated the country schools and replaced them with educational complexes staffed by departmentalized specialists offering fragments of the curriculum to students herded into their classrooms. Goodlad and Anderson (1959, pp. 143-168) suggest that teachers and students in the complex systems are faced with much the same problem as production workers

when it comes to relating their particular task to the whole. They face the same hazards to mental health when relevancy is not established.

If these indications are well founded it is easier to account for the lack of meaning and relevancy in many of today's school programs.

Further delving into educational research reveals that the method of grouping students also has an effect on the extent to which learning takes place. Two of the more promising approaches appear to be team teaching and individualized instruction.

Rollins (1964, p. 110), Klausmeier and Wiersma (1965-1966, pp. 238-242), and Sharkan (1963) indicate that team teaching is effective for either gifted or slow learners, to a degree in excess of that experienced by average students. Team teaching has been found as acceptable as the more traditional approaches by both teachers and students (Bloomenshine, 1959, pp. 217-219; 1960, pp. 181-196), (Bloomenshine and Brown 1961, pp. 160-168).

Conner and Ellena (1967, p. 306) contend that team teaching will increase in use in vocational education programs where specialization is essential. Cluster oriented programs founded on commonalities among several vocational areas will almost certainly find need for the team teaching approach. This need has been recognized for some time. MacKenzie (1950, p. 59) and Smith (1950, p. 14) suggests that the

curriculum should center around a major interest or concern. Smith's argument is that occupational groups are found to form social pockets within society at large. This is attributed to greater identification with persons with similar skills and background than with persons outside the particular occupational field. Smith would prefer to see this identity taught in the schools by teachers who understood the required skills and concerns of each occupational area. This is particularly appropriate to vocational and technical curricula. Any curriculum development approach should be able to include these factors and render an integrated program compatible with the specific needs of each member of the group.

While team teaching requires a considerable amount of planning which is difficult to schedule during the normal teaching day, there are other significant disadvantages. Facilities, according to Inlow (1966, p. 302), pose a far more formidable problem. Team teaching requires special facilities in the form of space for large group gatherings. The rationale is that specialists present materials to large groups of students and then divide into smaller groups for follow-up activity and discussions.

Alpren (1967, pp. 16-17) claims every approach to school organization tends to be artificial except individualized instruction. Not only is it an ideal method of instruction but it completely solves the problems of student grouping.

Glaser's "project Oakleaf" exemplifies some of the aspects that makes individual instruction ideal, according to Alpren. In Glaser's program students, as a result of diagnostic tests, are placed on a pattern of studies suited to their individual abilities and differences. Within the program, the probability of two students being at the same place at the same time is remote.

The Problem

Logically a problem arises. Is there a method of organizing the curriculum content into a meaningful structure spanning several subjects, yet flexible enough to enable implementation by means of team teaching or individualized instruction?

Parallels between industry and education were drawn earlier to demonstrate that some of the issues appear to be common. The solution to the problem just posed may, therefore, lie in the ability of educators to capitalize on the experiences of industry.

While gearing for highly specialized production industry did not, for long, neglect to consider the worker, nor to provide an underlying structure which maintained all of the independent activities moving toward a common goal. The control was insured by implementing one of a variety of network planning systems, most notably Program Evaluation and Review Technique (PERT) or the Critical Path Method (CPM). These systems are management tools for

defining and coordinating the activities that must be accomplished to complete project objectives on schedule. To achieve this the systems offer techniques for; integrating activities, improving decisions, statistically describing uncertainties, and focusing attention on critical activities.

Purpose of the Study

The purpose of this study was to outline an approach to the development of curricula for selected vocational education programs at the senior high school level, utilizing network-based management technology to facilitate the integration of content from several subjects into a structure amenable to either team teaching or individualized instruction.

Assumptions

There were several assumptions upon which the proposed approach to curriculum development was based.

1. It was assumed that programs in vocational education, when developed concurrently with related academic subjects in a manner adaptable to team teaching or individualized instruction, will be the most effective in terms of student achievement and economy of resource expenditures.

2. It was assumed that teaching efficiency and effectiveness will increase if teachers implement curriculum programs they have shared in developing.

3. It was assumed that students will function more effectively if they are able to meaningfully recognize the instruction they receive as a part of a whole, rather than simply fragments of unrelated subjects.

4. It was assumed that organizational problems of education and industry are sufficiently related to allow generalizations of problem solutions from industry into education.

5. It was assumed that the curriculum can be divided into a series of short-range learning objectives that can be organized into programs aimed at achieving long-range objectives.

Research Questions

Six interrelated research questions focused on during this study were:

1. How can the content elements of vocational subjects and related academic subjects be identified and organized into networks by utilizing PERT networking techniques?

2. How can the identifiable interrelationships of subjects offered concurrently to students be manipulated so that all activity moves toward a common goal?

3. Can the criteria be developed for dealing with the interrelationships among subjects offered sequentially?

4. How can several subject specialists function as a team, each pursuing activities which lead students to a common objective, even though constrained by conventional classrooms and facilities?

5. What means can be identified for adapting this approach to individualized instruction?

6. What are the preliminary steps in preparing student programs and schedules, providing instructional material control, and managing program revisions?

Significance of the Study

The significance of the proposed approach to curriculum development is the same as the significance gained by using network-based management systems in industry--efficiency. Efficiency in educational programs can be achieved in several ways.

Frazier's (1966) study demonstrated that integrated approaches for specific groups of students could lead to improved efficiency through increased achievement by the students.

Inlow (1966, p. 302) indicates that team teaching generally requires capital expenditures to provide the specialized areas for student/teacher interaction. The proposed approach increases efficiency by enabling specialists to follow independent curriculum paths, in isolated classrooms, and yet enjoy the pursuit of mutually shared objectives.

Many of the vocational programs strive to serve students within a wide range of individual abilities. To achieve success in a program, individual differences must be dealt with insofar as possible. The proposed study offers efficiency by delineating a plan whereby students can enter into a form of study where they can progress at their own rate in individual programs.

Methods and media of instruction, as well as the curriculum content, are continuously exposed to scrutiny and

change. One of the aims of this study has been to demonstrate how change factors can be incorporated into the basic plan so that the curriculum is always undergoing improvement. While perfection may be elusive in the curriculum, the curriculum need not be destroyed by even large changes in its body or structure.

All of these factors favor expenditure of extensive effort to develop a curriculum technology that effectively moves curriculum development for vocational education programs from a theoretical position to a position of practical application.

Though an attempt to provide a curriculum development technology in Industrial Arts has been made by Yoho (1969) through use of "snap maps", there is little technology available for structuring programs in vocational education (Cochran 1970, p. 91). On the other hand, Cook's (1966) suggestion that PERT be used in curriculum development projects and Werner's (1968) research into applicability of PERT in structuring mathematics and science programs provided clues to areas of research that proved fruitful.

<u>Operational Definitions</u>

<u>Content</u> is defined as the principles and concepts, the learning material, for a particular course. It may consist of either products or processes which can be performed on the products.

<u>Individualized instruction</u> is a mode of instruction

organized to the extent that a student can pursue a program independently at a rate and in a direction suited to his needs and interests.

Networks are defined as flow diagrams of planned events or objectives, their interdependencies and interrelationships.

Student programming is the arrangement of learning experiences required for an individual student to follow to attain the goals of his choice.

Team Teaching is a mode of instruction whereby specialized teachers share the responsibility of implementing programs of learning. The team teaching activity is traditionally carried out in specially designed schools.

Vocational curriculum is defined as a core of technical courses and associated related subjects which, together, prepare a high school student with occupational level skills and attitudes.

Method of Inquiry

The method of inquiry into the proposed approach entered two areas. First, the criteria were sought for developing curricula for vocational education and other disciplines, particularly mathematics and science which frequently augment the technical courses. Secondly, network-based management technology was examined for aspects applicable to this study. The latter included network development, time estimation, interfacing, network integration, summarization, evaluation, and terminology. Finally, an integration of the two avenues of pursuit resulted in the curriculum development approach outlined in the subsequent chapters.

To establish direction to the study the following sequence of steps were undertaken.

1. Major curriculum development parameters were drawn from the related literature and organized into a model to identify the boundaries within which the proposed study was to function.

2. The feasibility of utilizing network-based management technology in curriculum planning was demonstrated by showing that educational programs and industrial programs are similar with respect to: pursuit of definable long-range goals; large numbers of participants in the program; need for clearly delineated decision-making criteria; need to incorporate the activities of individuals into a common plan; need for periodic evaluations to identify potential problems.

3. Fundamental principles of network-based management technology were reviewed to the extent necessary for application in curriculum development.

4. It was demonstrated that either new programs or existing objectives could be developed into networks comprised of events representing educational milestones which can be handled by networking technology.

5. It was demonstrated that network integration could identify critical areas, and once integrated the combined networks represent a well organized curriculum which tends to reduce the tendency towards fragmented instruction. Further, a method of network summarization was demonstrated which provides educators with meaningful indicators of progress of both students and programs.

6. This approach was shown to be suited to contemporary curricula where content is subject to rapid change. The ramifications of small changes in one part of the curriculum may be reflected throughout the entire curriculum. It was further demonstrated that the curriculum can remain stable in the face of staff attrition.

7. The approach was shown how to provide effective control of instructional materials, student programming, and scheduling.

8. As the final step, a management plan was developed to serve as a guide in implementing this approach to curriculum development.

Limitations

The proposed approach was limited to an examination of the problems of development of curricula for vocational education courses and their related academic subjects.

The primary aim of the study was to devise a means of structuring several subjects into a meaningful whole. A secondary aim was to develop a means of preserving the program structure during implementation by either team teaching, where facilities would normally be a constraint, or individualized instruction.

Finally, Taba (1962, p. 10) suggests that a curriculum should contain; a statement of aims and objectives, selection and organization of content, patterns of instructional methodology, and a set of evaluative criteria. This study was

limited to developing criteria for; delineating program aims and objectives, selecting and organizing the content, and evaluating and revising the results, with emphasis on effective utilization of resources. Instructional methodology was omitted because it must be compatible with the learning environment and can, most effectively, be selected by the teachers who are a part of that environment.

Many aspects of curriculum development have been over-simplified in this study in an effort to consider the total realm of activity which must be attacked through a network-based management systems approach. The suggestion that the curriculum can be broken down into a series of learning objectives may be called into question. While learning may take place incidentally, and in the course of other activities, it can be argued that incidental learning can just as easily occur in conjunction with a more structured curriculum. The advantage in the latter position lies in the fact that greater learning efficiency can accrue from a well planned curriculum with incidental learning providing an added dividend.

The proposed approach represents the development of an innovation. Until sufficient objective evidence can be accumulated on which to base an acceptance or rejection, the value of the approach will rely largely on the type of application and the vigor with which the application is pursued.

Delimitations

The bounds of this study lie in the domain of vocational education at the senior high school level. While a degree of generality is envisioned in application of this approach, examples cited in the study were limited to those vocational courses most familiar to the author, specifically automotives, electricity, electronics, and pipe trades, all of which require varying degrees of facility in mathematics, science, English, and human relations.

Summary

Several factors have given rise to this study. Production-line workers in industry, when unaware of how their individual roles fit into the whole, often exhibit some form of mental illness. Parallel trends have been identified in education. A second factor stems from research which indicates that team teaching is more effective than traditional departmentalized instruction as a means of reaching those students whose abilities deviate most widely from the central tendency of the group. Even more desirable are programs that are structured around the needs of each individual. Network-based management technology, because of its success at relating individual activities to the program whole, was selected as a means of resolving the problems of developing vocational education curricula for implementation by either team teaching or individualized instruction.

Overview of the Other Chapters

Chapter II reviews the current literature related to curriculum development. Focus is on factors to be considered in developing a viable curriculum for vocational programs. Chapter III identifies several of the network-based management systems and offers a rationale for selection of PERT as the most appropriate for use in curriculum development, together with a discussion of its methodology. Chapter IV presents the plan for developing a curriculum through application of PERT technology. Chapter V discusses implementation of the curriculum to achieve either individualized instruction or team teaching. Chapter VI presents an evaluation of the proposed curriculum development approach. Chapter VII outlines a management plan of use to schools or systems planning to utilize the approach recommended in this thesis. Chapter VIII contains conclusions drawn from the study, together with some comments on generalizing the approach.

CHAPTER II

REVIEW OF CURRICULUM DEVELOPMENT LITERATURE AND THEORETICAL FRAMEWORK

Scope of Literature Review

The review that follows is not exhaustive in the sense that it probed to the depths of curriculum development but rather it is expansive in that it sought the parameters vital to a functional curriculum development approach. The identified parameters were subsequently organized into a model which served as a guide during amplification of the approach to vocational education curriculum development which follows.

Taba (1962, p. 6) declares that a theory of curriculum development is non-existent, Wann (1966, p. 26) reiterates the statement, and the continuing lack of a theory is confirmed by Foshay and Beilin (1969, p. 276). One may well ask--why is there no curriculum development theory available after all the years of concern?

A synthesis of the literature reveals that the lack of a comprehensive curriculum theory is partially the result of preoccupation with tradition, goals and the means of achieving them, and theory making as an end in itself (Foshay and Beilin, 1969, p. 276). Lack of a curriculum theory accounts, in part, for the innumerable methods being used to formulate programs of learning experiences for students.

Curriculum Development Parameters

Many educators have come forth with recommendations of what a curriculum theory should encompass. Foshay and Beilin (1969, p. 276), who have examined much of the relevant literature, state that

> When a comprehensive curriculum theory is built, it will have to take into account not only the learning methods and teaching methods ("Strategies of instruction" and the like) but also the nature of the knowledge to be learned, the nature of the student who would learn it, and the nature of the societal responsibilities shared by the teacher and the student.

One of the problems appears to be that curriculum theory specifications are too encompassing. Beauchamp's (1961,p. 17) suggestion that development of sub-theories should precede general theories may be the most expeditious route toward a curriculum development theory. It may also be prudent to insure that the theory be practical--that is to say capable of implementation at the appropriate planning levels. Any curriculum development technology must be practical in terms of the demands placed on the planner's time and abilities.

The review of curriculum development theory begins with an examination of several contemporary models. As cited, Foshay and Beilin deem nature of knowledge and nature of the student as elements of utmost concern. Between the two lies a screening process comprised of the screen of student/teacher interaction and shared responsibilities, coupled with a methodology screen which modifies the student's view of knowledge. The model, Figure 1, makes it easy to

envision situations where students associated with different teachers may acquire entirely different exposures to the knowledge available.

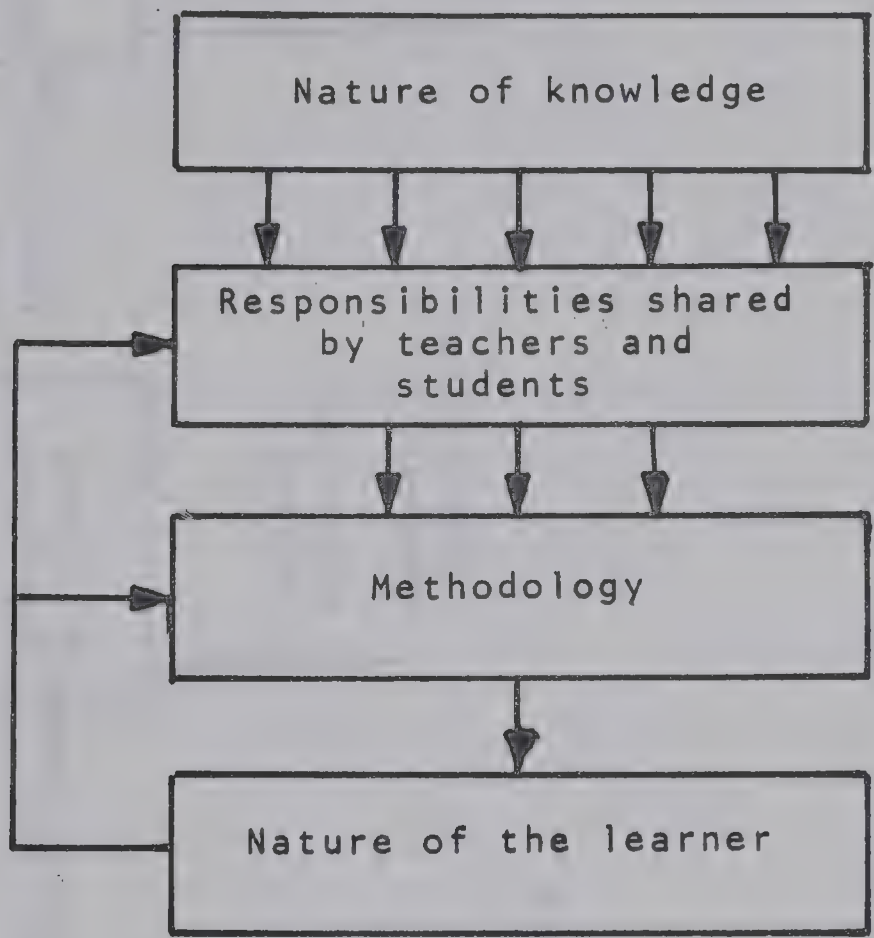

Figure 1. Foshay and Beilin's concept of the forces shaping the curriculum (1969, p. 276).

Saylor and Alexander (1966, p. 7) formulate a model, Figure 2, of curriculum development which encompasses decisions ranging from the cultural level to the classroom level. The model reflects the view that aims and objectives stem from several determinants and serve as guides for curriculum decisions. Specialists at the curriculum planning level make decisions regarding appropriate content and organization which are expressed in curriculum plans. From the plans stem strategies for implementing the curriculum decisions in the classroom.

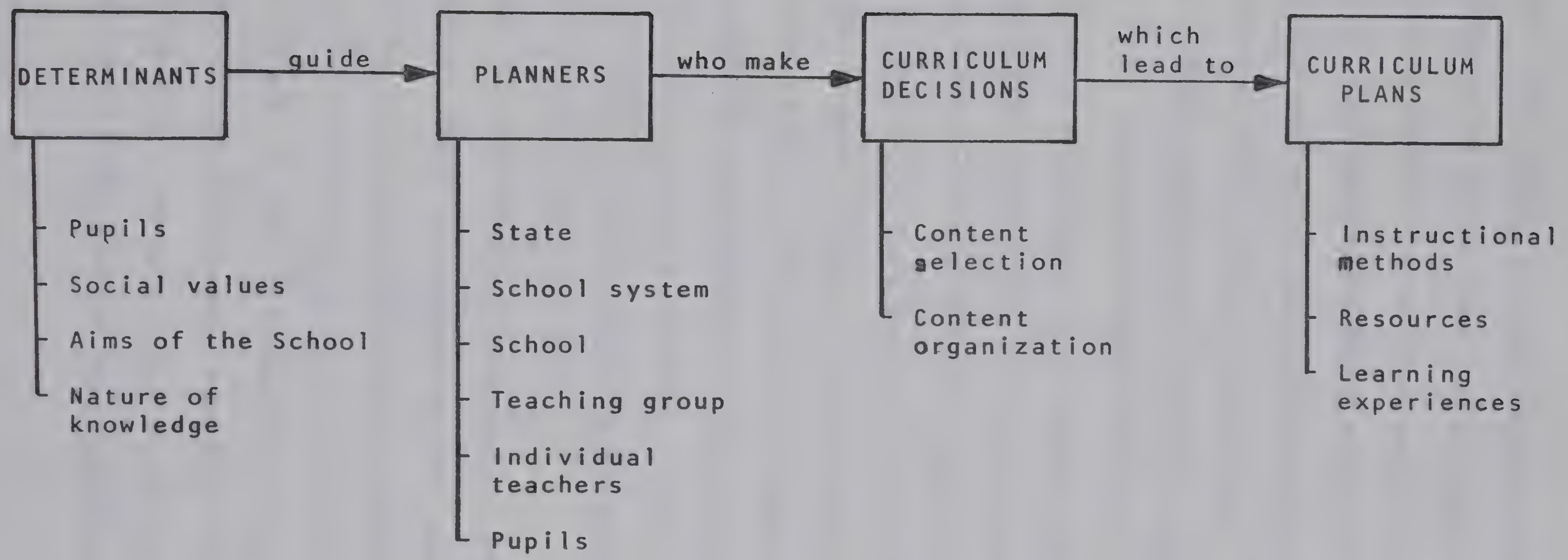

Figure 2. A model of curriculum development adapted from Saylor and Alexander (1966, p. 7).

Robert Fox (1969, p. 223) offers another model, Figure 3. The pattern of Fox's model is similar to those already cited. The curriculum stems from cultural guidelines. Successive levels of decision-making results in eventual formation of a series of learning experiences intended to achieve the expressed cultural objectives.

Yoho (1969) approaches curriculum development for Industrial Arts through systems analysis. He regards a problem or a global objective, as a system, and by using multiple levels of analysis identifies all of the component pieces. While the approach is fruitful as a means of selecting and organizing content, it does not easily accommodate decision-making at the several levels of curriculum planning. The approach would be most effective in situations where the levels of decision-making are compressed into a narrow range--perhaps within a classroom. In a situation of this type the aims and objectives and the selected learning experiences can be entirely justified by the teacher.

Another curriculum plan proposed by the American Industry Project (Gebhart, 1968) is subject to the same criticism. The aim of the plan is so specific that it constrains decision-making to a few individuals at the same level of responsibility.

Taba's (1962, p. 10) delineation of the functions involved in curriculum development captures the essence of most of the cited models. Her position, which is similar to Tyler's (1950, pp. 1-2), points to; selection of aims and

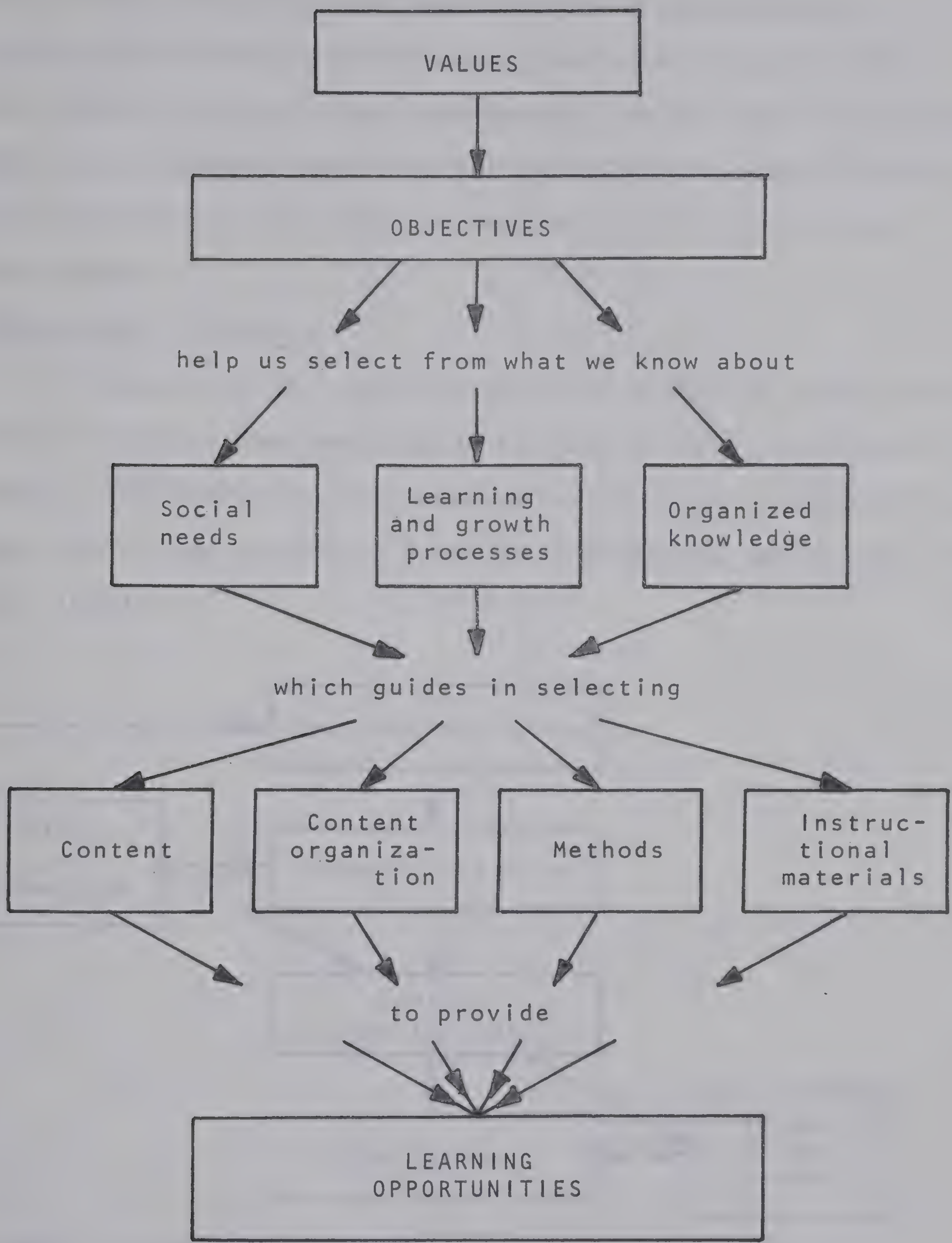

Figure 3. An adaptation of Fox's model of curriculum development (1969, p. 223).

objectives, selection and organization of the content, selection of learning experiences, and evaluation, as the key factors in curriculum development. While specifying what must be considered Taba does not restrict the several levels of planning activity which become involved in curriculum development.

Theoretical Framework

Integration of Taba's criteria with that of Foshay and Beilin envelops the spectrum of concern to curriculum developers. Reflection of the integration is shown in Figure 4, a model which was used as a guide throughout the development of this thesis.

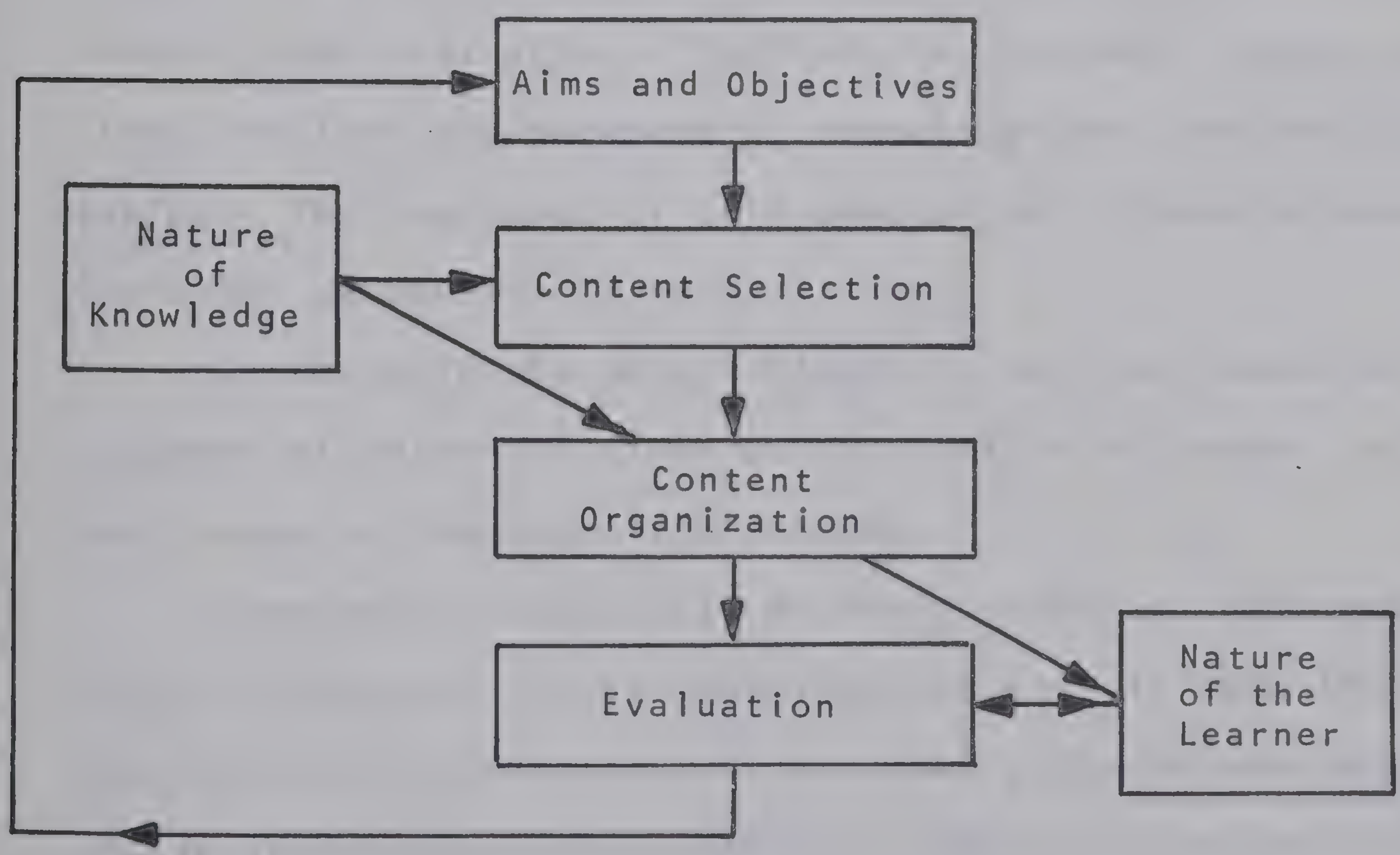

Figure 4. A model of curriculum development

The model is a departure from that recommended by Taba since the selection of learning experiences has been omitted. Justification for this omission lies in the fact that the selection of learning experiences will vary among teachers and learning environments, and therefore cannot be specified. Though the decisions are made in the classroom, they will ultimately be included in the evaluation cycle. The ideal situation would be to attain a level of curriculum development that was teacher independent--all variability of the evaluation data being due to student/curriculum interaction.

The model identifies eight parameters of concern to the curriculum developer; aims and objectives, content selection, content organization, nature of knowledge, nature of the student, and evaluation. Implicit in the model itself one finds the last two parameters, communications and decision-making. The remainder of this chapter will focus on each of the eight parameters in turn.

To be valid the model, Figure 4, must be compatible with a number of points of view--particularly with regard to divergent views of the cognitive process.

Congruency occurs with Bruner's (1961, p. 33) hypothesis that, "Any subject can be taught effectively in some intellectually honest form to any child at any stage of development." It can be detected in the manner in which the nature of knowledge and the nature of the learner interact through appropriate content selection and organization.

Similarly, face validity can be observed with respect to Piaget's theories where the learner is regarded as being in constant interaction with knowledge--cognitive growth progressing in sequence with biological and experiential maturation (Baldwin, 1967).

Aims and objectives. Since decisions made outside a classroom are more general than decisions made inside the classroom, it is important to be concerned with the possible levels involved. Goodlad (1968, p. 221) identifies the levels in terms of remoteness from the classroom as instructional (classroom), institutional, and societal. Curricular decisions occur at all three levels though the types of decisions vary depending upon the level involved.

Taba (1962, p. 10) and Tyler (1950, pp. 1-2) both place aims and objectives at the starting line of curriculum development. The aims and objectives serve as the source of all plans and the target toward which the educational processes move. Specific objectives, sub-objectives and ultimately teaching experiences stem from the global aims and objectives in a pyramidal fashion. Goodlad (1963, pp. 25-26) stresses that objectives (ends) should be the first clue for determining the learning (means) to be arranged in the curriculum. This is not suggesting, though, that Goodlad, or Taba, advocate top-down structuring of the curriculum. The reverse is true. Both propose starting from the aims and objectives and working upward (Foshay and Beilin 1969, p. 277).

As it will be seen in the next chapter, PERT is a top-down planning device which starts at a terminal point and unrolls--always exposing precedent objectives. The two approaches, however, may not be at crossed purposes. PERT, while demanding a top-down delineation of objectives, also demands a bottom-up development of the program to meet the objectives. The problem simply hinges on whether curriculum planners are speaking of objectives (ends) which should flow top-down or implementation plans (means) which emanate from the lowest planning levels. Since each terminal objective has a sequence of precedent objectives, a set of goals for a secondary vocational program could easily expose the program for preceding grades down to kindergarten.

Content selection. The program objectives and priorities should give rise to the initial direction for selection of the content (NEA, School for the Sixties, 1963, p. 50). They, in essence, postulate a top-down approach (already discussed) to planning where major objectives divide into sub-objectives or content elements.

Inlow (1966, pp. 12-27) suggests that content should be selected on the basis of; centrality in the program, essentiality and universality, the nature of man, the nature of the universe, and balance. These aspects are constrained by; vertical sequence, pupil readiness, and agency appropriateness.

While many program developers begin and end with fragments of knowledge, or learning material, defined as content,

Parker and Rubin (1966, pp. 55-56) suggest the inclusion of processes in the curriculum, processes being defined as operations which can be exercised on the content elements.

Content organization. Figure 4 highlights the importance of organization of the selected content. Silvius and Bohn (1961, p. 47) suggest that before a teacher can organize a course, the course to subject and subject to curriculum relationships must be known. However, with demands for relevancy and program integration the teacher must be given a means of seeing across subject lines, thus enabling identification of intersubject relationships.

Herrick (1950, p. 37) stresses the need for subject organization in planning because important decisions are more consistent and open to evaluation and improvement when the pattern of factors is seen as part of some understandable structure or design. Administrative reviews of progress pertaining to both students and the program are more meaningful when the pattern of factors is seen as part of some understandable structure or design. Administrative reviews of progress pertaining to both students and the program are more meaningful when they are able to see where they have been and where they are going.

The vertical organization of curriculum should consider the logical structure of the subject, relative difficulty in terms of the student's maturity, and the relationship to other subjects the student might be taking (NEA, School for the Sixties, 1963, p. 67).

Some argue that structure is implicit in subjects such as mathematics, science, and the technologies, but unknown in subjects such as English and history. Ford and Pugno (1964, pp. 31-105) demonstrate that there are structures underlying each of these areas.

In the model shown in Figure 4 it can be seen that organization is the only direct link between knowledge and the learner. Teacher/student interaction does not provide alternate routes to knowledge, but rather aids in following along the planned route. With organization of the curriculum content occurring at the intersection of the model, great care must be taken in insuring that the organization leads to an optimum curriculum structure.

Bruner (1961, 17-32) endorses a structured curriculum because it serves the following purposes. Understanding a framework makes a subject more understandable. It serves as a stimulus to human memory. It improves transfer of learning from one specific to another. A structure reduces the intervening gap between elementary and advanced knowledge. A final advantage achieved through structure is that common principles which reoccur in several disciplines need to be learned only once and then reapplied.

Evaluation. Evaluation leads to program revitalization. Goodlad, O'Toole and Tyler (1966, p. 13) point out that a curriculum has a life expectancy of about fifteen years and is generally ineffective within seven or eight years. This

can be avoided by continuous evaluation and revision, but the basic approach to curriculum development must be one that is compatible with constant revision.

Taba (1962, p. 12) includes as part of the curriculum plan the need to determine what to evaluate and the way to accomplish it.

Bloom, Englehart, Furst, Hill, and Krathwohl (1956) recommend that objectives be specified and formulated into a hierarchy. Elements from within the hierarchy can be used as evaluative devices to determine program effect on students.

Mager (1962) and Popham, Eisner, Sullivan, and Tyler (1969) suggest careful specification of learning objectives in behavioral terms so that evaluation becomes more nearly a GO/NO GO process. When applied to every objective and sub-objective specification, not only can students be evaluated, but the entire program is open to critical evaluation.

Unfortunately, according to Frymier (1969, p. 13), educators pay only lip service to evaluation. While most of the theorists include it in their considerations, few plans follow through with an evaluation cycle that revitalizes the curriculum. Without revitalization the curriculum has a short life indeed.

Nature of knowledge. Dictionary definitions of knowledge are not very fruitful in shedding light on the nature of knowledge. Ayer (1956, pp. 11-14) divides knowledge

into two states; "knowing that", and "knowing how". Taba (1962, p. 172) and Parker and Rubin (1966, pp. 55-56) regard the things to be learned as being of two varieties; content, and processes. Schwab (1964, pp. 6-30) points to knowledge as being comprised of an unnumbered set of disciplines. Disciplines are described as having three characteristics: membership and organization of the constituent parts; ability to extend knowledge through enquiry; ability to make qualitative judgments on the new discoveries through internalized mechanisms.

Another point of view is implicit in the taxonomies (Bloom et al, 1956), (Krathwahl, 1968). It is contended that learning takes place on three dimensions; cognitive, affective, and psychomotor. If an aspect of the nature of knowledge is to be knowable, then it must lie within these three dimensions.

Arrangement of some of the cited concepts into a model, Figure 5, enables some interesting considerations.

	Cognitive domain	Affective domain	Psychomotor domain
Content "Knowing that"	I	II	III
Process "Knowing how"	IV	V	VI

Figure 5. A model of the nature of knowledge.

Though no attempt is made to describe the nature of knowledge in each cell, it is worthwhile to consider two of the cells. The learning of content in the cognitive domain, Cell I, is nothing more than rote learning. Since the affective domain is not entered there will be no feeling for the facts--they will be learned without interest. The same would be true of purely psychomotor skills, Cell VI. Those who contend that learning should be meaningful are really saying that all learning should ideally encompass all three domains, or at least enter the affective domain. The latter position is supported by Hebb (1964, p. 20) in a discussion of arousal. Arousal is viewed as the common denominator of emotions and motivations and is approached through the affective domain. It is crucial to optimal learning, that is learning must be an emotional process.

<u>Nature of the learner</u>. The model in Figure 4 is useful when attempting to individualize the curriculum. Though some would argue for an average set of attributes describing the nature of the student, the really important consideration is the variance of each of the attributes. Only after the variance is accounted for can a curriculum planner claim that the curriculum is suited to individualization.

The issue is further complicated since the set of attributes is itself on a continuum of change and with each generation the rate of change becomes more rapid. Herold (1970, p. 23) argues that the rate of change expands an

individual's life.

> The expansion is not measured in terms of clock time, but in terms of experience, or what we might call subjective time. For a living being, time seldom passes according to the clock but is judged in terms of experience. This is an interesting paradox here, in that time spent in interesting pursuits passes rapidly, whereas time spent in idleness and illness drags. Yet in recollection, we exactly reverse this, and we remember time largely in terms of interesting experiences. But it is recollection that counts, since that is when stored information is used. Thus, the paradox is resolved in that we may conclude that more experience and more information are subjectively equivalent to a longer life.
>
> To carry the thought further, consider a man who lived 70 clock years from, say, 1850 to 1920, and add up his potential experiences as a measure of 70 experience years. His great-grandchildren, living from 1910 to 1980, could, if they fully absorb their potential of information (experience), easily exceed 400 experience years. Their children, 1930 to 2000 A.D., may exceed 700 experience years.

To the curriculum planner these comments have tremendous import. The child entering school at the turn of the century had an age of about seven experience years. In the 1940's a child may have had an age of about 40 experience years upon entering school. Today's children may have experiential ages, upon entering school, of up to 70 years. Yet one may well find the curriculum over the last 100 years hasn't changed commensurately. Even so, fruitful research has been carried out in many areas in an attempt to create improved curricula and learning environments.

The nature of the learner has been pursued in three areas by behaviorists, developmentalists, and Gestalt

psychologists.

Following the footsteps of Watson and Skinner are such behavioral theorists as Staatz and Staatz (1963) and Gagne (1965). Their concept of learning as postulated by Gagne (1965, pp. 31-61), maintains simply that complex learning is comprised of building blocks which at the lowest level are little more than responses to stimuli.

The developmentalists, of which Piaget is representative, assume a more global stance and regard learning as dependent upon biological and experiential maturation (Baldwin, 1967), (Maier, 1965).

The Gestalt theorists see the learner as striving to develop patterns of organization, of trying to fit the pieces into a meaningful whole (Deese, pp. 203-205, 460).

The true nature of the learner probably encompasses all of the theories. Implications, however, are such that learning may be most easily achieved if it is presented: in congruence with biological and experiential maturation of the child; in small steps; with sufficient redundancy so that re-inforcement establishes the behavior; as a whole before examining the parts.

Decision-making. Curriculum development is comprised of many decisions at several levels, specifically societal, institutional and instructional. The societal level is identified with school boards and departments of education, the institutional level with schools, and the instructional

level with classrooms. Due to its fundamental importance in curriculum development, multi-level decision making will be disucssed in greater detail in Chapter 3.

Communications. A curriculum development approach that does not deal specifically with communications is analogous to assembling all of the parts to a computer system and omitting the interconnecting wires. Neither system can function.

Though the communications link in the model is self-evident, it tends to be overlooked too often. Planning and evaluation must move up and down the model. In other instances communications must move horizontally school to school or teacher to teacher. PERT, according to Archibald and Villoria (1967) and Cook (1966) is a means of graphic communication which concurrently offers a straight forward approach to program planning. It utilizes a method of task division which assigns each program participant with specific goals or objectives. These goals or objectives give rise to activities which can be arranged into networks and manipulated to optimize time/resourse expenditures. Activity uncertainties are expressed in the form of statistically derived probabilities of achieving scheduled dates or milestones. Individually developed networks can be combined and recombined into larger networks until management has a completely specified plan for pursuing specific goals. Once the integrated networks are acceptable as representative of the goals, management is required to

exercise decisions only on exceptions to planned progress. When decisions are made at any level, the impact is reflected throughout the program in terms of new critical areas. Network-based management systems provide an effective means for communicating information, organizing objectives, and formulating decisions required in curriculum development.

Summary

A review of the literature has revealed eight dimensions which must be regarded when developing a curriculum.

1. Curriculum development stems from a statement of aims and objectives.

2. The nature of knowledge is of importance because it influences what should be taught as well as how it should be organized.

3. Content selection is aimed at fulfillment of the aims and objectives.

4. Content organization is important since it is instrumental in revealing the nature of knowledge to the learner.

5. The nature of the learner is of importance for two reasons: first the curriculum developer must know how the cognitive processes work; secondly the curriculum developer must know the influence stemming from biological and experiential maturation.

6. Evaluation is vital to the continuing improvement of the curricular program.

7. Curriculum development is contingent upon effective decision-making made at varying levels of remoteness from the classroom.

8. Communication is essential to convey to all participants at all levels the aims and objectives, the implementation plans, and the evaluation.

These topics have not been pursued in depth in this chapter, rather an attempt has been made to interrelate them into a theoretical framework. Subsequent chapters will expand the framework into a practical approach to curriculum development.

CHAPTER III

DECISION-MAKING AND NETWORK-BASED MANAGEMENT SYSTEMS

Overview

Decision-making is vital to curriculum development. This chapter focuses on decision-making and network-based management systems to an extent sufficient to justify selection of PERT as the basis for a curriculum development approach. The latter portion of the chapter is devoted to a discussion of PERT technology.

Decision-Making

There is a tendency for most organizations to increase the amount of resources invested, the number of employees, and the number of products handled. As these elements of the organization increase and decentralize at a linear rate, the interactions among the elements increase at an exponential rate. Such is the case in curriculum development programs. Conceding that an individual is limited in his ability to mentally manipulate a multiplicity of variables (Miller 1965, pp. 241-267), it is apparent that processes must enter into organizational planning that increase the efficiency of the planning function. The initial focus of this chapter is on decision-making and network-based management systems which effectively facilitate decision-making.

While on the one hand schools tend to consolidate, there

is a counter tendency to decentralize within the consolidated system. Several advantages of decentralization are: executives are nearer the point of decision-making; time and talents of executives are better utilized; decisional qualities increase as problems are simplified at lower operational levels of the organization; and routine paperwork and coordination are reduced through shorter communication lines (Dale 1952, p. 157). Drucker (1964, p. 51) points to two other areas of advantage; decentralized operations provide a source of potential executives, and all operations are exposed to executive scrutiny--"weak managers cannot ride . . . on the coattails of successful divisions."

Centralized control is one key to solving some of the problems of decentralization. Centralized control can be realized in several ways; through centralized programming and planning, by granting limited authority, through provision of specialist services to the lower echelons, and through uniform accounting and reporting practices (Dale 1952, p. 148).

Each aspect of centralized control entails decision-making. Occasions for decision-making, according to Barnard (1951, p. 201), originate at three locations: from activities occurring at any management level in the organization; from directives originated by superordinates; and by appeals from subordinates. These levels correspond to the societal, institutional, and instructional levels noted by Goodlad (1968, p. 221). Further, Barnard (1951, p. 203) stresses that

the most important facet of decision-making is in knowing when to make decisions.

> The fine art of decision-making consists of not deciding questions that are not now pertinent, in not deciding prematurely, in not making decisions that cannot be made effective, and in not making decisions that others should make.

Simon (1960, p. 1) defines decision-making as a process consisting of; finding occasions to make decisions, finding alternate courses of action, and in choosing the most promising course. Griffiths (1959, p. 94) sub-divides the process into the following steps: recognize, define and limit the problem; analyze and evaluate the problem; establish the criteria for judging a suitable solution; collect relevant data upon which to base a solution; apply the evaluation criteria; and finally, put the solution into effect and evaluate the results. Simon (1960, pp. 5-8) continues the analysis of decisions by classifying them into two categories--programmed and non-programmed. Programmed decisions are those where the decision-making process relies heavily on experience in similar situations. Non-programmed decisions have no counterpart in experience and therefore rely on creativity. Decisions in either category may be made by individuals or in groups.

Change is another element to be reckoned with in decision-making. White (1969, p. 103) points out that the high rate of failure in technology-based organizations is due to failure to plan for change. "Organizations must anticipate change, not react to it." To a degree this applies to all organizations,

educational institutions included. The relevance of White's observation stresses the need to examine carefully Simon's concept of non-programmed decisions. To the extent that an organization is involved in change, more decisions must be derived through a non-programmed process and fewer derived through experience. Man's varying rationality (Simon, 1957, pp. 75-77) coupled with organizational change reduce both individual and group derived programmed decisions to a low level of acceptability.

Since curriculum development is concerned with change, the non-programmed decision-making process offers great potential in deriving solutions to curricular problems.

March and Simon (1958, pp. 190-199) postulate a sequence of events which reduce unique problems to manageable sub-goals and sub-tasks. Their steps take the following pattern: initiate ideas or recognize unique problems; execute a means/end analysis to place the problem in perspective and evaluate its potential impact; problem factorization where the problem is re-defined in terms of a group of sub-goals; establishment of a goals and sub-goals hierarchy. This process is congruent to Miller's (1963, pp. 65-71) process of establishing a Work Breakdown Structure as a first step in the development of a Program Evaluation and Review Technique(PERT) program.

Barnard, already cited, cautioned against making decisions before sufficient information had been gathered. The input of information into the decision-making process is crucial and occurs in many ways. Emery (1967, p. 97) identifies a basic difference in sources of information between

centralized and decentralized organizations.

> In amplifying higher-level plans into lower-level plans each organizational unit adds information. In a "centralized" organization, most of the information comes from the higher levels; in a "decentralized" organization, the lower levels tend to supply a relatively greater proportion of information.

White (1969, p. 105) points out that information is a product that must be controlled. However, information control, censoring or otherwise, tends to place an individual in a position of power. A potential problem in loosely organized units lies in the possible usurpation of power illegitimately through information control.

Synthesizing the concepts of March and Simon, Barnard, Emery, and White, decentralized decision-making should combine the efforts of several levels of the organizational hierarchy. Activities at the lowest level must be directed toward achieving goals set by the nearest superordinate level and so forth until management can see the entire program plan in detail from their several vantage points. It was to achieve this level of management control that network-based management systems were developed in 1957.

Network-Based Management Systems

Network-based management systems as already implied, utilize an approach to problem solving similar to that described by March and Simon. Long-range goals are subjected to repeated divisions. The complex goals become relatively simpler when examined in their constituent parts. A program involving thousands of employees over several years may be

broken down into smaller tasks requiring a few employees over shorter time intervals. The approach recommended by Miller (1963) and Archibald and Villoria (1967) requires that employees, specified by the Work Breakdown Structure, divide the task into discrete events which may be regarded as milestones--unambiguous indicators of progress. These events are arranged into a network, or flow diagram, representing the optimum approach to attainment of the assigned goals.

The second phase of network development entails preparation of time estimates. An empirical approach is utilized which capitalizes on the fact that employees involved in planning have some experience at similar tasks. The time estimates tend to bracket the expected activity time in a prescribed manner. The three estimates of activity time are; the most optimistic, the most likely, and the most pessimistic times. Using these three estimates in a statistically weighted formula, the estimator can calculate the expected activity time for each network event with a 0.5 probability of completion on or ahead of schedule. The summation of event times gives the expected completion time for each network, again with a 0.5 probability of being on or ahead of schedule upon completion (Archibald and Villoria, 1967, pp. 76-90, 448-454).

After task networks are optimized they must be integrated into a larger network representing the goals of a broader organizational base. Interface areas must be

considered so that undue delays and problems are not unnecessarily created (Archibald and Villoria, 1967, pp. 214-231). Resolution of the interfaces between networks represents the bargaining aspects of decision-making suggested by Cert and March, (Lane, 1967, p. 136).

Once the networks are timed, interfaced, and resources allocated (if a costing program is utilized), the data may be either transferred to a computer format, or if the task is small, handled manually. In either case key events are identified for first and second order summarization so that condensed networks can be presented to management. As they are submitted to periodic review these key events highlight problems for management--essentially forcing decision-making by exception (Malcolm and Rowe, 1967, p. 222). The organizational structure required for implementation, outlined by Bonney (1967, p. 272), is structured into a model, Figure 6.

The effectiveness of such programs, especially PERT, is a direct function of information. Schoderbek (1967, p. 44) contends that:

> The amount of information necessary for a particular individual in a decision-making situation will therefore be proportional to the amount of uncertainty initially surrounding the problem. The greater the uncertainty the greater will be the amount of information to reduce it.

One of the derivatives of the time estimating cycle in the program is the approximate standard deviation (one-sixth of the difference between the pessimistic and optimistic dates) of the event activity time. The standard deviation is

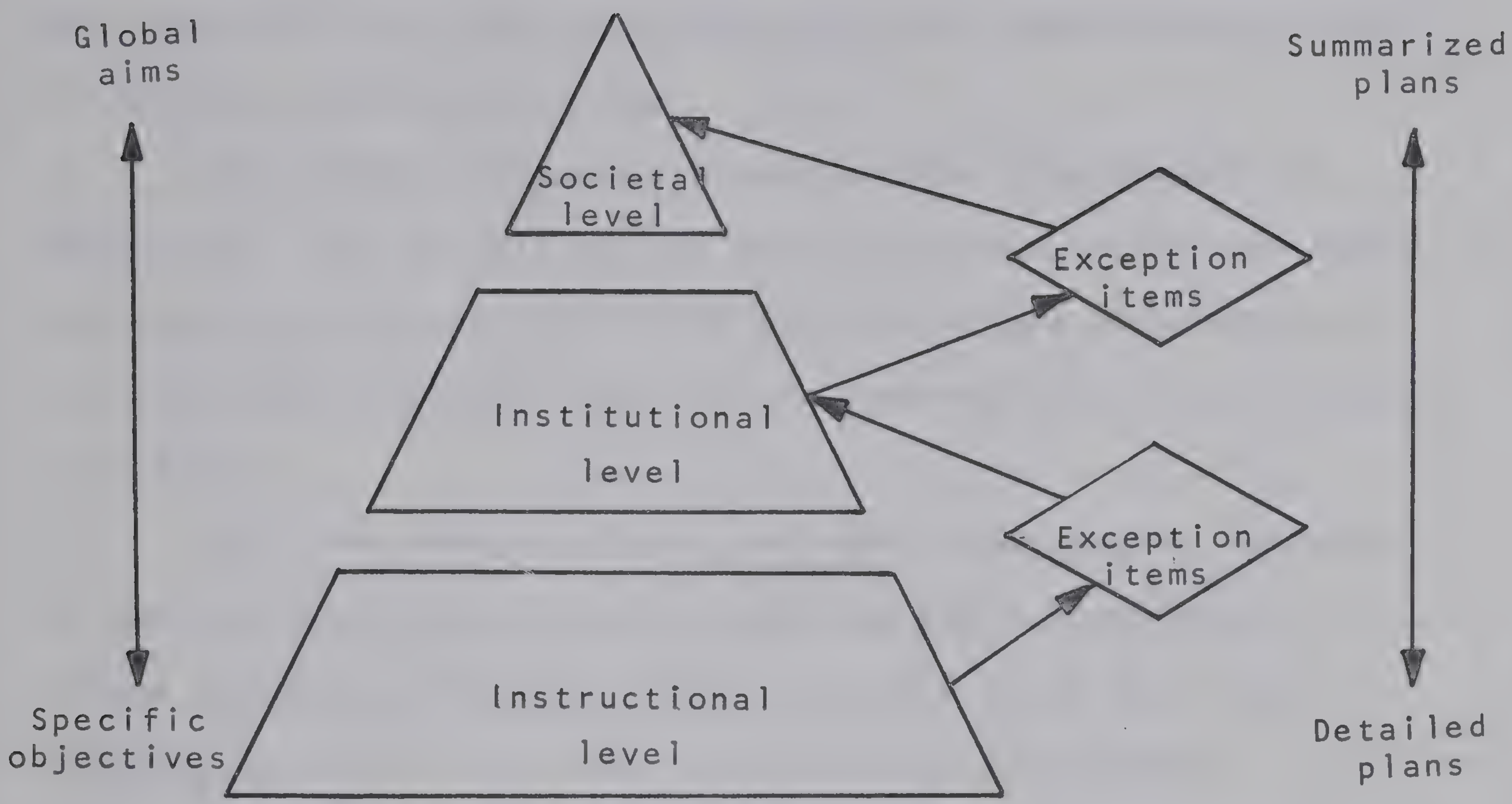

Figure 6. A model reflecting communication flow in an organization utilizing management by exception.

equivalent to the uncertainty factor cited by Schoderbek, and immediately identifies events where increased information should be focused.

Virtually all of the network-based management systems discussed by Woodgate (1964) fall into one of two types--the Critical Path Method (CPM) of PERT.

In application the CPM is an activity or job oriented plan best used on well defined projects or continuous process operations. Maximum benefit from the CPM program is realized when the project is; under one dominant organization, free of uncertainties, and centralized.

PERT is event oriented and best applied to; large and hard to define programs, programs with large degrees of time and cost uncertainties, and programs with wide geographical distribution and complex logistics.

One final difference hinges on the expenditure of resources. CPM activities can be accelerated by the increased application of resources. PERT activities are more uncertain and increased resource expenditure improves the situation only to a point.

For the reasons cited, and since the program followed by each student while obtaining an education constitutes a unique sequence of events, PERT is deemed to be the most appropriate vehicle for use in curriculum development. It is able to accommodate many uncertainties stemming from such variables as; teacher effectiveness, student differences, and application of different approaches to learning.

The selection of PERT is supported by the research of Werner (1968) in the use of PERT as a means of ordering interrelated units of science and mathematics to achieve individualized instruction at the secondary level.

Program Evaluation and Review Technique (PERT)

As related by Archibald and Villoria (1967), the scientific approach to management is not new. Frederick Taylor's time and motion studies first looked at facets of tasks and made precise measurements of their elapsed times. Henry Gantt, at the turn of the century, developed a plan for incorporating time and activities into a form of bar

chart commonly known as Gantt Charts. These charts served as the most common management technique until the post-Korean War era. Customer demands for schedule performance required adoption of a modification to the Gantt Chart to include milestones. Milestone dates appeared as clauses in contracts. Modified Gantt Charts, however, exhibited two significant shortcomings; first, they failed to reflect task interdependency, and secondly, they failed to reflect uncertainties. All of this changed when CPM and PERT were developed in 1957.

So that the reader can fully appreciate how PERT is to be used in the curriculum development process, an understanding of PERT is essential. The remainder of this chapter will be devoted to sketching a brief outline of the PERT method of planning.

The PERT network is made up of two basic elements; an arrow which represents a time consuming activity, and a balloon representing an event. A simple segment of a network is shown in Figure 7.

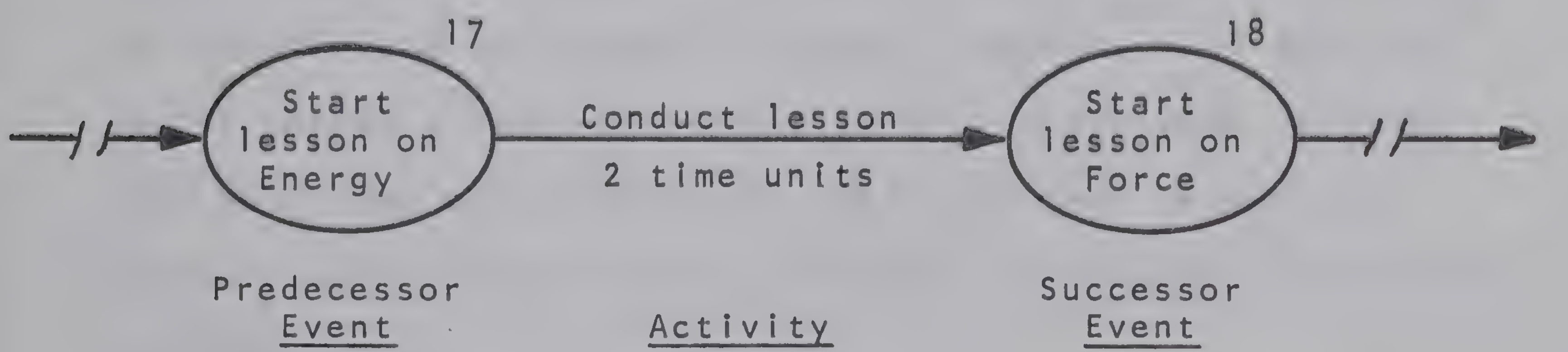

Figure 7. The basic elements of a PERT network (Archibald and Villoria, 1967, p. 17).

In preparing a network representation of the assigned task, certain criteria must be observed. Arrow heads entering events represent constraints imposed by predecessor events. Arrow heads leaving an event represent constraints on successor events. Successor events cannot begin until all predecessor constraining events have been completed. With the exception of the start and end events, all events must have both predecessor and successor events. Upon initial completion of a network it is examined to insure that it represents the optimal method of executing the task.

Planning a PERT program, which in essence follows Griffith's five steps, begins as soon as the global objectives are delineated. The planners first task is to extract from the delineated objectives, the specific ends together with both target dates and target costs. With this information a Work Breakdown Structure (Figure 8) is developed, together with a Gantt Chart reflecting specific milestones. Each task of the Work Breakdown Structure is assigned to the appropriate group in the next lower level of the organizational hierarchy. An unambiguous assignment of tasks, together with detailed Gantt Charts allows each group to plan their work while at the same time eliminating the confusion that occurs when agencies are unintentionally assigned overlapping responsibilities.

Objectives	Dept. A	Dept. B	Dept. C	Dept. D	
Objective 1	✓				
Objective 2		✓			
Objective 3			✓		
Objective 4		✓			
Objective 5				✓	

Figure 8. The Work Breakdown Structure

Each participating group develops a more detailed Gantt Chart which reflects their plans for implementing the objectives. Miller's (1963, p. 24) method of network development derived directly from a Gantt Chart is shown in Figure 9.

Since the network is a method of time planning, it is necessary to estimate each activity time in the reviewed network. While some occasions allow the use of single time estimates, the preferred method is the three time estimate, those being the most optimistic, the most pessimistic, and

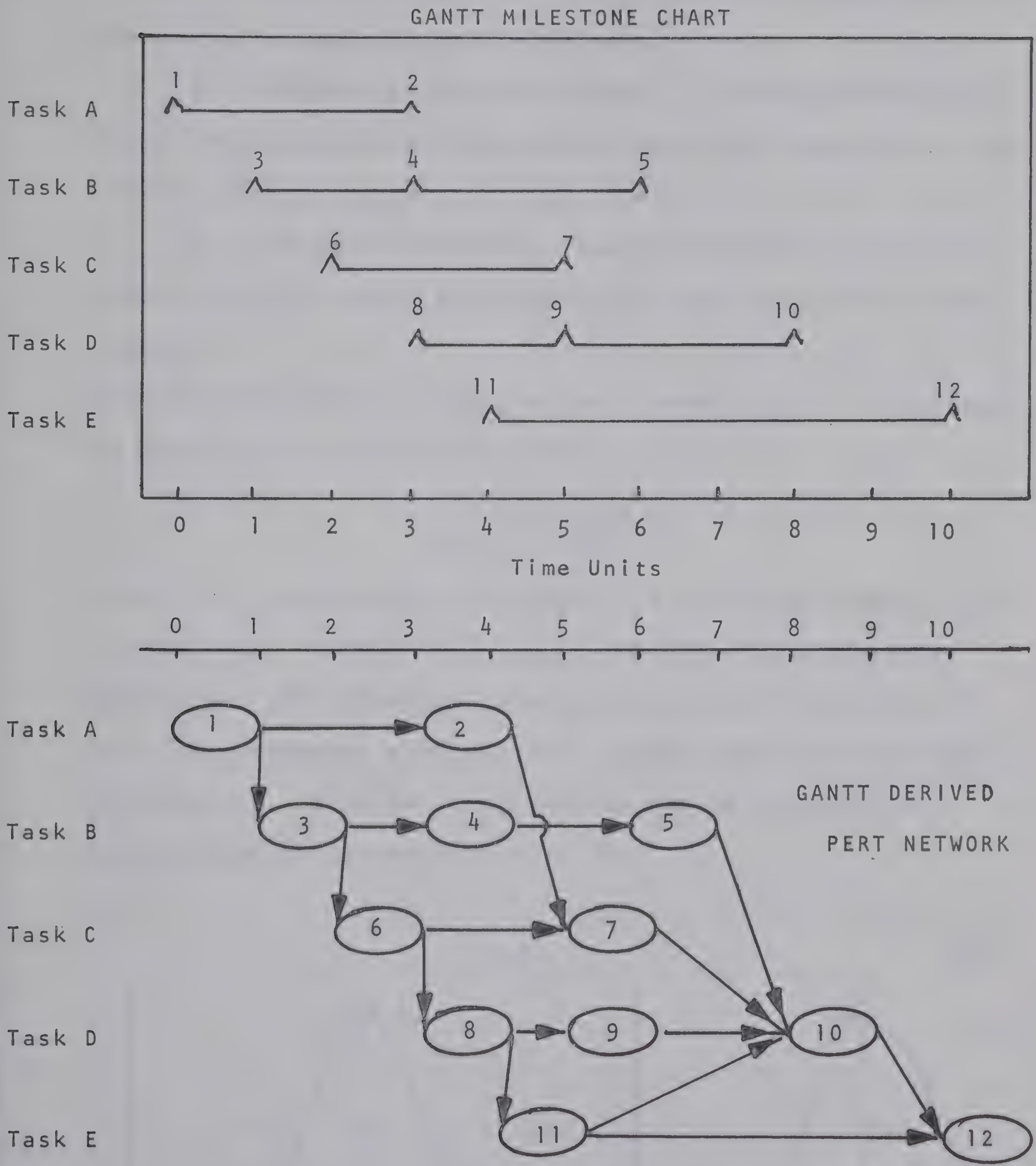

Figure 9. PERT network derived from a Gantt Milestone Chart (Miller, 1963, p. 29).

the most likely. Time estimating criteria are the following:

1. The most likely time, m, is the time estimated for the activity under normal conditions.

2. The most pessimistic time, b, is the worst time lapse anticipated, barring acts of God. The pessimistic time will be encountered once in 100 times.

3. The most optimistic time, a, is the best possible time and it too has a probability of occurring once in 100 times.

The expected activity time for each event, t_e, is calculated by means of the following formula.

$$t_e = \frac{a + 4m + b}{6}$$

Since b - a represents the range of the time estimates, 1/6 of the range represents an approximation of one standard deviation. The expected time t_e represents the median of the time estimates with one-half of the cases falling above or below it. A normal distribution may be expected to approximate the curve in Figure 10a.

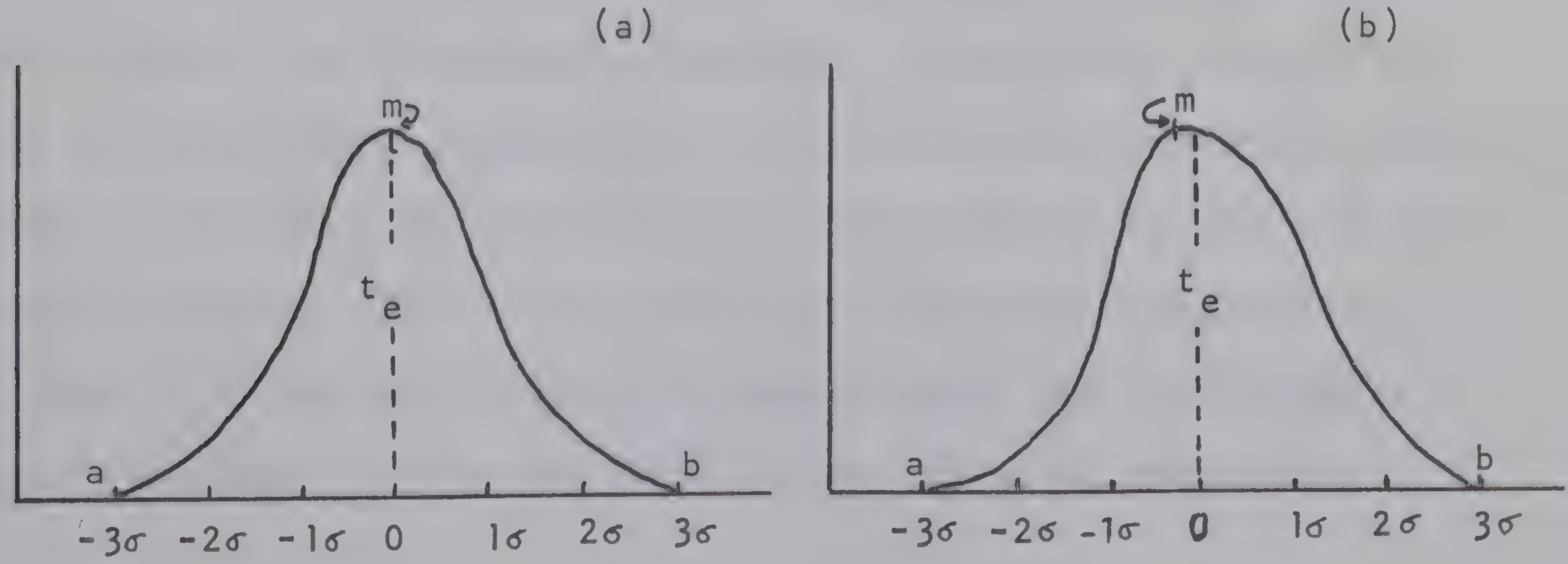

Figure 10. Distribution of time estimates (Archibald and Villoria, 1967, pp. 76-90).

Practice indicates that there is a greater likelihood of events occurring late than early, therefore, the selection of m determines the actual shape of the distribution. The result is seen in Figure 10b. In this light an estimate of 2, 5, and 8 time units represents a poor estimate. It is much more likely that the pessimistic time will deviate more widely from the most likely time than will the optimistic time. A more realistic time estimate would be 4, 5, and 8 time units. A rule of thumb suggests that activity time estimates for any work package should not exceed approximately three percent of the total network time. Longer time estimates indicate lack of information available to the planner.

Since the start and end events of a network correspond to milestones in the assigned objectives, it is important to establish that the network activity can be accomplished in the period of time allocated. The earliest expected completion date for a network event, T_E, can be determined by summing the activity times, t_e's, from the starting event to the end event. The expected completion date T_E, should occur on or before the scheduled milestone. The latest allowable date for any event completion, T_L, can be determined for each event by starting at the end event and summing t_es toward the starting event. The slack time T_S is found by subtracting T_L from T_E. The path with the least slack, or the greatest negative slack, is the critical path. This is the path to

which the administrator must give the greatest attention when reviewing the program.

It is possible on programs that are composed of many networks to find constraints on events imposed by interfaces with other networks. Network validation involves checking the critical paths of each network to make certain that interface events do not unduly delay the program. Figure 11 indicates the relatedness of networks in a program. Inasmuch as each network represents a different group of people, constraints on events indicate areas where the bargaining aspects of decision making are very much in evidence.

Another feature used in the larger PERT programs is a network summarization. While each working group deals with a network of about 75 to 100 events, a program as seen from a senior administrative position could easily consist of 100,000 events, a figure well beyond the data handling limits of man. To reduce the data, key events are identified in each network. On larger programs computers calculate the critical paths of these events. The result is a vastly simplified, yet extremely accurate, network for presentation to senior management.

For programs implementing PERT TIME/PERT COST, it follows that the next step is to allocate resources to the activity paths. The costing procedure is similar to the timing methods. Total network costs must be reviewed and revised until they too fit within the guidelines prescribed

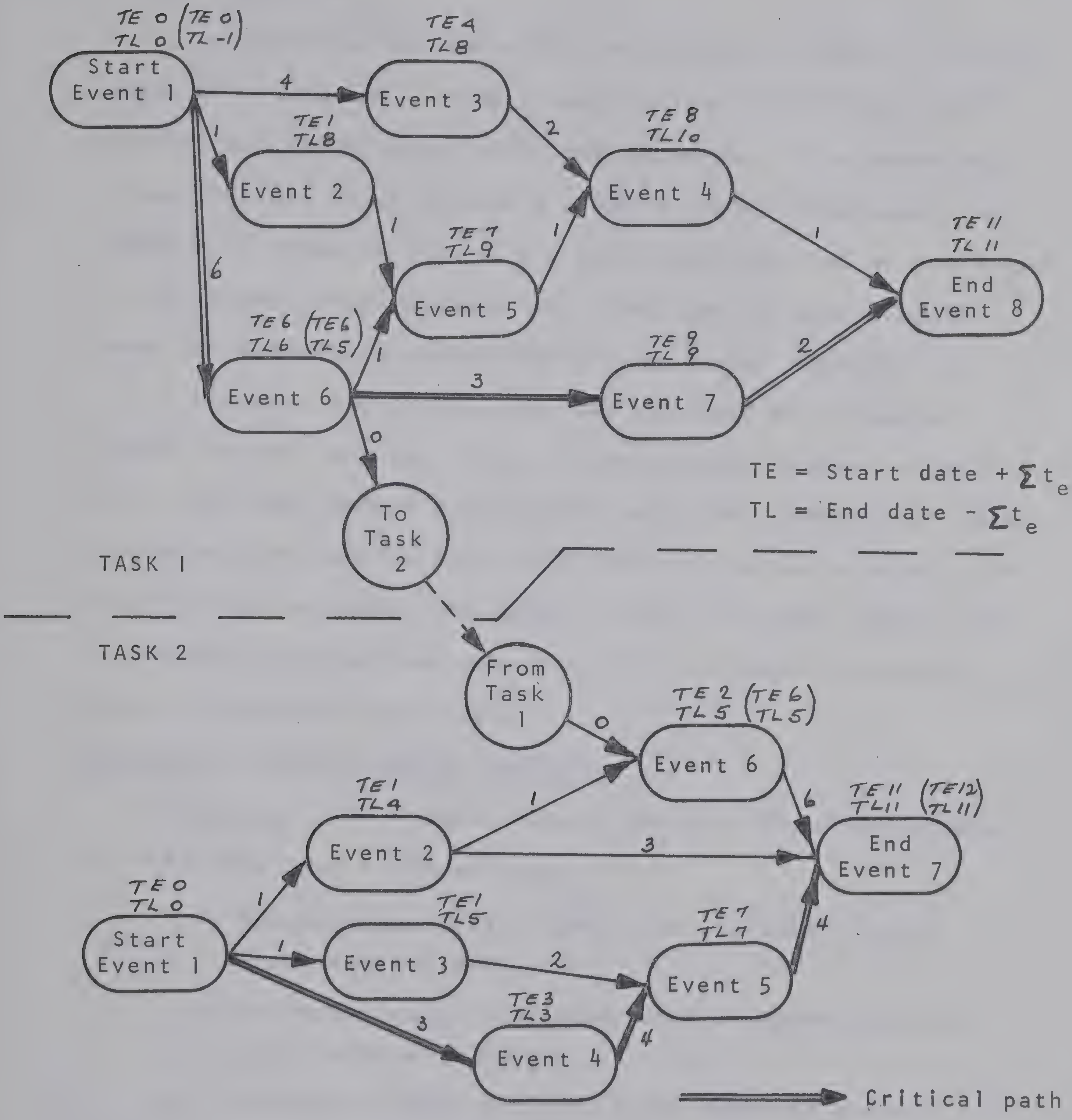

Figure 11. Network validation. The problem occurs when Event 6 of Task 1 places a constraint on Event 6 of Task 2 to such an extent that the Critical Path of Task 2 is shifted through Event 6. Figures in parentheses represent the timing after the interface of the two tasks.

by the objective.

In practice the networks can be handled manually or by means of a computer. Manual applications of PERT are best carried out by using calendarized networks. A calendarized network is one drawn to scale along a linear time base. An example is shown in Figure 9. Since the position of the event in the network represents time, slack can be read directly from the network, a useful feature on manual applications.

Networks must be updated and reviewed on a regular basis, usually weekly. This allows several reviews of each activity, even though they occupy only short lengths of time. At the end of each review exceptions to planned progress are analyzed to determine the impact on the critical paths, and to develop alternatives when the critical paths increase beyond allowable tolerances.

<u>Glossary of PERT Symbols and Terms</u>

<u>Symbols</u>. Only those symbols central to any discussion of PERT have been included here.

a - The most optimistic time with a probability of occurrence of 0.01.

b - The most pessimistic time with a probability of occurrence of 0.01.

m - The most likely activity time expected under normal conditions.

t_e - The expected elapsed activity time calculated by means of the following statistically weighted formula.

$$t_e = \frac{a + 4m + b}{6}$$

TE - The earliest expected date for an event to occur.

TL - The latest allowable date for an event to occur.

TS - The scheduled completion date for an event.

Terms. Only those terms central to any discussion of PERT have been included here.

Activity - The resource consuming element of the network and represented graphically in the network by an arrow. In this study learning experiences leading to objectives are treated as activities.

Constraint - The relationship between two events where one event must precede the second event. The arrowhead on the activity lines interconnecting the two events designates the constrained event.

Dummy activity - Activity lines that consume no resources.

Earliest expected time, TE - The earliest time by which an event can be completed, calculated by summing t_e's from the start event.

Event - A discreet occurrence in the program. In this study events and objectives are used interchangeably.

Expected time, t_e - The calculated time that an activity is expected to take. In PERT applications it is derived from a statistically weighted average of three time estimates and has an 0.5 probability of occurring on schedule or earlier.

Gantt Chart - A bar chart that reflects activities and milestones, either in series or in parallel, but fails to reflect interevent relationships.

Latest allowable time TL - The latest time at which an event can occur without delaying program completion, calculated by summing t_e's from the end event towards the start.

Loop - A circularity within a network where a successor event constrains a predecessor event. Networks cannot contain loops.

Network - A pictorial representation of the completed plans for a program. A network consists of events and activity lines ordered to reveal the sequence in which events occur.

Scheduled completion time, TS - The scheduled completion time for the network.

Slack - The difference between the latest allowable time TL and the earliest expected time TE (TL-TE).

Work Breakdown Structure - A subdivision of objectives with assigned responsibility for achievement. In this study a Work Breakdown Structure is equated with a Program Breakdown Structure which divides programs at the institutional level and a Course Breakdown Structure which divides tasks at the instructional level.

Work package - A cluster of events making up a specific segment of network. In this study the term will be used interchangeably with curriculum module.

Summary

Decisions are more consistent and open to evaluation when the pattern of factors is seen as part of some

understandable structure or design. PERT is a method of developing plans in response to assigned aims and objectives. While the aims and objectives emanate from superordinate levels, the planning takes place by specialists at the lowest level of activity. Each superordinate level, through which the aims and objectives were amplified, sees a common plan of implementation but from different vantage points. Network changes occurring at the lowest level are reflected by means of the evaluation process to the upper levels with each level concerned only with exceptions to planned progress.

CHAPTER IV

DEVELOPMENT OF THE NETWORK-BASED CURRICULUM

Overview

Between the aims and objectives of education and the ultimate outcomes lies an area which, though explored, is traversed with greatest difficulty. The area encompasses the selection and organization of the curriculum content to meet prescribed educational aims and objectives. The difficulty in traversing the terrain is due to several factors. Divergent philosophical and psychological conceptualizations have the effect of distorting the views--few people see the terrain exactly the same way. An increase in curricular productivity requires either agreement on the best set of criteria to be used, or a means of integrating the several sets of criteria into a single mapping. It is towards the latter that this chapter is directed.

Following a review of several theoretical positions, it is demonstrated that curriculum content can be selected and organized into a viable curriculum network by adhering to PERT technology.

Related Research

The first step toward integrating the theoretical positions necessitates examination of the theories. Taba (1962, p. 10), in outlining a set of activities involved in

curriculum development, includes selection and organization of content. Though selection and organization of content is further illuminated in a model of curriculum design (Taba 1962, p. 438), it leaves the curriculum worker with little more than a frame of reference and not an approach to curriculum development technology--with what to consider but less clearly how to proceed. Development of a curriculum development technology is extremely important since much of the selection and organization of curriculum content occurs at the classroom level where little time is available for developing complex strategies if a viable curriculum is to be assembled at a rate commensurate with demands placed on the teacher by class sizes and schedules. A curriculum development technology would reduce the planning task to manageable size by offering a concrete sequence of steps leading to the desired outcome.

Of the several determining factors influencing content selection and organization, perhaps, as suggested by the curriculum development model in Figure 4, the nature of the subject, and the nature of the students, are critical. Taba's (1962, p. 438) model suggests other factors which include; scope of the content, sequence in which it should be presented, continuity within the educational program, and integration with other concurrent learning experiences.

If Taba's approach and that of Gagne (1965) were compared on a curriculum development strategy continuum, they would be found to lie in polar opposition. Where Taba is

general in approach, Gagne, as a representative of the behavioristic approach to selection and organization of curriculum content is specific. Gagne's (1965, pp. 31-61) theory suggests that the types of learning fall into a hierarchy. At the lowest or simplest level of the pyramid is signal learning, followed by S-R learning. From these elemental building blocks stem learning variations referred to as chaining, verbal association, multiple discriminations, concepts, principles, and problem solving, with the latter involving the most complex learning. His hypothesis is that a problem solving situation can be analyzed into constituent parts until the most complex behavior to be learned lies in the area of signal learning, S-R links, chaining, and associations.

The developmentalist Piaget, regarding education from another point of view, sees learning and biological maturation as closely allied. He fosters the theory that there is a period of maturational readiness when concepts at a specific level of abstraction can be learned most easily. His studies indicate that acquisition of concepts, such as conservation, is problematical if sufficient biological maturation has not taken place. Similarly, lack of a suitable background of experiences can delay concept acquisition. In essence Piaget is committed to the position that maturation and experience form the basis for all learning, and learning takes place only on a firm foundation (Baldwin, 1967),(Maier, 1965). If

Piaget's theory is correct, and more and more theorists are adopting his position, curriculum developers must contend not only with the sequence of curriculum content, but they must be mindful that the sequence is essentially invariant and intimately related to the biological and experiential maturation of the learner.

Gestalt theories describe much of the complex learning in terms of processes and strategies. Problems take on the form of schematic anticipations, or to use Ausabel's (1965, p. 111) concept, advance organizers. Solutions to complex problems stem from cumulative sequences of solution methods coupled together. Cumulative coupling can be classified into either matching or successive substitution sequences, or a combination of both (Newell, Simon, and Shaw, 1965, pp. 153-155). To the curriculum planner, attention to the Gestalt approach to learning imposes two constraints--both processes and strategies or structures must be included as part of the curriculum.

Attempts have been made to formulate taxonomies of behaviors or objectives for the use of educators (Bloom et al., 1956), (Krathwahl, 1968). This work identified three dimensions, cognitive, affective, and psychomotor.

Like Gagne's hierarchy, the taxonomies are a variety of top-down delineation of content elements stemming from the global objectives of the curriculum. Either approach applied to any of the elements of Figure 5 might be expected to yield

fruitful results.

Departing from consideration of psychologically derived approaches to content selection and organization opens the way for consideration of several other approaches to curriculum development.

Yoho's (1969) "orchestrated system" is one attempt at solving the riddle of curriculum development in the field of Industrial Arts. Broad objectives for a course are structured into what Yoho refers to as "snap maps" which are flow charts of objectives. Each of the objectives from a first level map explodes into a more precisely defined chart at the second level. This process proceeds through as many as five levels at which time very specific concepts have been identified. Sequence and integration are delineated by the maps. Scope and content is handled through a sampling process--enough samples of each concept are selected and used to insure that student's acquisition of the concept meets the criterion behavior.

While Yoho's systematic approach results in a viable curriculum, it poses two significant problems. First, maps are prepared at each level of planning. By the time the fifth level has been exposed, the volume of maps has increased to cumbersome proportions. It should be pointed out that levels are simply stages in Yoho's frame of reference. One person may do the planning of all five levels. The second problem stems from the fact that relationships among elements of different maps are not easily handled since each map is

expanded as a unit.

Vocational curricula aimed at development of occupational skills frequently resort to what is tantamount to the time and motion studies common in the first two decades of this century. One approach of this sort is outlined by Bollinger and Weaver (1955, pp. 50-67). Jobs form one dimension to be examined with operations forming the second dimension of a matrix. While this process is useful in exposing content, it fails to provide clear guiding principles with regard to sequence, continuity, and integration.

As suggested by the preceding discussion, there are many ways of selecting the content and scope of the curriculum. Furthermore, each discipline contains inherent indicators of scope as well as sequence and continuity (Ford and Pugno 1964). Intradisciplinary integration may be revealed by close content analysis but unless the discipline is understood exceedingly well, sequence and continuity may be seen only faintly and integration remains in limbo.

Yoho's strategy approaches a nominal technology of curriculum development in Industrial Arts. Provus (1969, pp. 242-283) adheres to a similar approach and suggests that the content be organized in terms of "terminal objectives" and their preceding "enabling objectives". As common to most strategies, integration is left to the student to achieve as he struggles with fragments of material gathered in several courses.

Unfortunately, none of the cited approaches offers suggestions of how to divide the teaching task when content crosses disciplinary boundaries. The following is an example of this: a simple physics problem immediately involves two sets of principles; principles from physics and principles from mathematics. The complexity increases when application of the principles is attempted in a vocational setting in any sort of integrated fashion.

Developing the Curriculum Network

The remainder of this chapter describes how PERT technology can be used to select and organize the content of the curriculum, while at the same time overcoming problems of integration across disciplinary boundaries.

Aims and objectives. The triggering mechanism for the curriculum lies with society whose consensus should be embodied in the aims and objectives of every educational program. To increase efficiency in the educational system, the aims and objectives should be stated clearly, preferably in behavioral terms. Behavioral terms are endorsed because they are measurable. This makes the objectives compatible with PERT criteria which requires programs to be expressed in terms of events--discrete happenings along the continuum of time.

Increasingly, curriculum theorists are defending behaviorable objectives as appropriate to curriculum development (Mager, 1962), (Popham, Eisner, Sullivan and Tyler, 1969). Popham (1969, p. 35) presents a matrix which defines the

nature of the possible objectives that may be encountered.

	Intended behavior	Unexpected behavior
Measurable	I	III
Unmeasurable	II	IV

Figure 12. A model of educational objectives adapted from Popham (1969, p. 35).

Ideally in the curriculum network, if only those objectives which fit cell I were used, progress through the curriculum could be measured precisely. Objectives falling into Cell II, although less desirable, may also be used, but the precision with which progress is measured tends to suffer. Cells III and IV represent variables that should be avoided in the curriculum as much as possible except when those desirable outcomes occurring in Cell III can be conceptualized and reassigned into Cell I.

Sullivan (1969, pp. 75-78) identifies the types of behavioral objectives that might be used. Each of these types can occur at any level of the taxonomy of objectives. The two structures can be combined into a 36 cell matrix which increases the scope of the types of objectives that can be specified.

	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
Identify						
Name						
Describe						
Construct						
Order						
Demonstrate						

Figure 13. A matrix of educational objectives.

The first requirement then, in developing PERT networks is that all of the objectives at the societal level must be stated in behavioral terms. This initiates the evaluation cycle and evaluation is important, since programs should be judged on their ability to meet their stated objectives and not by a comparison with other programs of questionable virtue. Program acceptance or rejection lies wholly in the merit of the objectives and the ability of the program to meet the objectives.

Assuming the societal level to be the Department of Education, the first subordinate level is the institution which might be the school board or the school, depending upon the organizational framework. Institutional level planning

entails first, acceptance of the aims and objectives set forth by the superordinate body, and secondly, further delineation of the objectives into specific subobjectives. The restated objectives might be specifications for a vocational program or modification of an existing program to serve a specific learner population.

Objectives at the institutional level stemming from societal aims and objectives, are arranged in a Program Breakdown Structure, portraying in one dimension the objectives and in the other dimension the units within the instructional level responsible for developing plans to meet the objectives.

If the institutional level is represented by the school board and the instructional level by the school, the Course Breakdown Structure facilitates the assignment of specific course or subject objectives within the school.

The terms Program Breakdown Structure and Course Breakdown Structure are synonymous with the term Work Breakdown Structure. In the context used in this thesis a Program Breakdown Structure identifies courses as a result of program planning, while a Course Breakdown Structure identifies topics comprising a course.

As high level plans are amplified into lower level plans, each organizational unit adds information. By following PERT methodology the classroom teacher is provided with a Course Breakdown Structure containing clear-cut objectives to be met in the classroom, but which stem directly from the societal planning level. When the aims and objectives are ultimately

met in each classroom they are also met at the societal level.

Though the discussion thus far suggests that aims and objectives emanate from the provincial level and are implemented at the classroom level, these levels may become compressed. In some instances aims and objectives may be established by the school board, the school, or even by the teacher, while in other instances aims and objectives may be introduced at all levels simultaneously. The important factor is that all of the PERT planning stages must be undertaken regardless of the separation among the levels of planning.

Once appropriate aims and objectives have been delegated the next phase of curriculum development is that of selecting and organizing the content to meet curriculum objectives.

Content selection and organization. By the time that the objectives have been subdivided at each of the several levels of planning, with each level adding information, the objectives arriving at the lowest level often resemble concepts and principles. In practice the aims and objectives assigned to the instructional level serve as the key determinant for the scope to be covered. By first using the techniques of Gagne, Bloom, Yoho, or any of the other available methods, together with the criteria for preparing behavioral objectives, the content can be selected. By adhering to PERT methodology, the content elements can be arranged to provide optimum sequence, continuity, and integration, either within a course or among several courses offered concurrently.

At the start the curriculum developer at the instructional level has specific objectives and a time frame (year or semester) to serve as guides. In the terminology of Provus, if the prescribed objectives are regarded as "terminal objectives" they must be analyzed for their "enabling objectives". The PERT process is congruent, the terminal events (objectives) are analyzed for all predecessor events. Those adhering to the taxonomies will develop a number of hierarchies, one beneath each of the objectives.

Again starting from the most global events, each predecessor event is roughly located in the specified time frame. By first placing the events on a Gantt Chart together with a suitable time base, it becomes possible to quickly develop a network by following the process illustrated in Figure 9.

With all of the events transfered into a network format it becomes necessary to examine each event carefully and consider its relationship to other events on the network. While a Gantt chart, or any other tabulation, fails to recognize relationships, they become readily apparent during the process of networking.

Before proceding to subsequent stages of network development, it is important to identify each network and each event within the network. This is accomplished by assigning a name to each network and a number to every event in the network, including the start and end events.

An example of a network representing a unit of an

electronics course is shown in Figure 14. It complies with all of the criteria established in the preceding discussions, and is ready for the steps which follow.

To this point PERT technology has provided the opportunity to establish scope, sequence, continuity, and intra-course integration. All of the courses a student may be taking sequentially or concurrently can similarly be integrated into a single program by a PERT process known as network integration and validation.

The teacher who teaches all subjects to a group of students is able to formulate cognitive maps of the subjects and their interrelationships. The resulting instruction facilitates understanding of these relationships by the students. With school consolidation and subsequent subject specialization, the teachers' ability to relate a specific subject to the whole curriculum often is lost. Though Brown (1954, pp. 281-282) and Goodlad and Anderson (1959, pp. 143-168) feel that a lack of understanding of one's own activity as it relates to the whole (job satisfaction) lowers morale and induces mental stress, remediation of this problem may lie in carefully fitting individual activities into a pattern which reflects the activities of a group. In PERT technology this process is known as network integration and validation.

Network integration is contingent upon only one factor--there must be at least two networks that have either concurrent or sequential relationships. The total integration of a set of

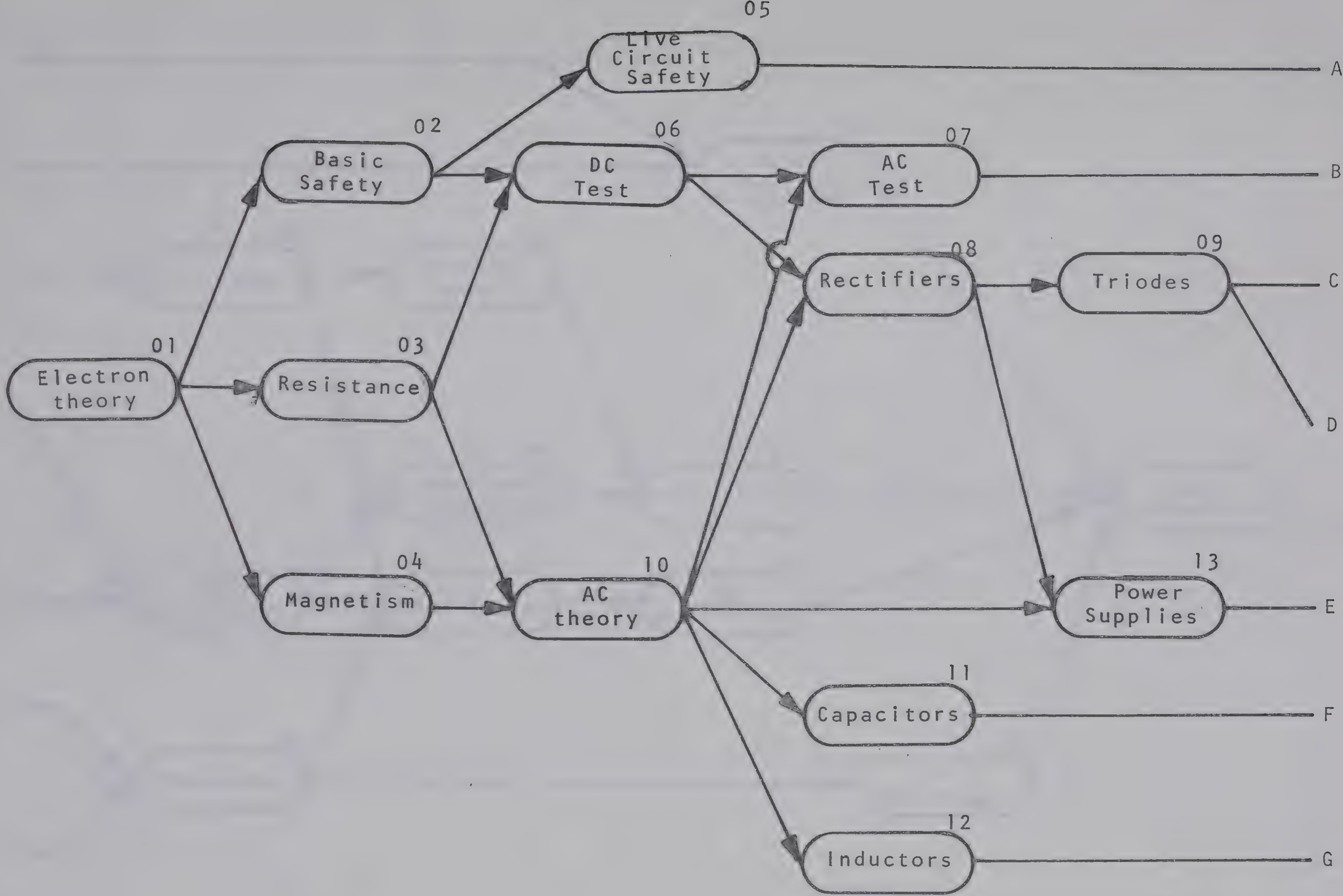

Figure 14a. Unit of electronics course, Part 1.

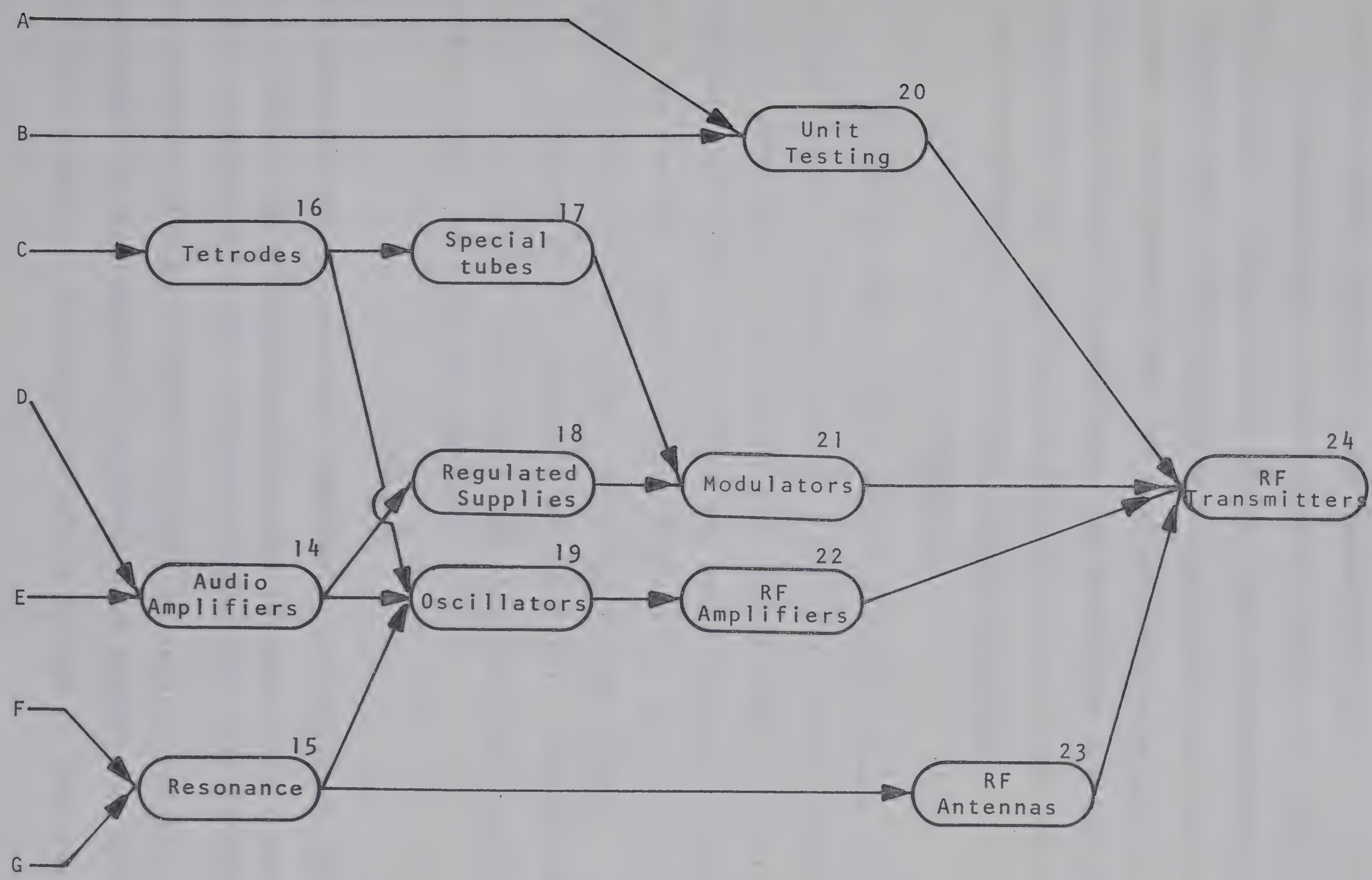

Figure 14b. Unit of electronics course, Part 2.

networks entails several stages; time estimation, interfacing and integration, validation, and summarization.

Network timing. Time estimating entails the use of the PERT method of three time estimates. The three estimates are; the most likely time (m), the most optimistic time (a) (one percent of the cases), and the most pessimistic time (b) (also one percent of the cases). To derive the expected completion time (t_e) requires substitution of the three estimates into the following statistically weighted formula.

$$t_e = \frac{a + 4m + b}{6}$$

As the estimator prepares time estimates there are several factors to bear in mind. First, it is more common to be late than early. Therefore, when estimating it is well to remember that excellent students may get a concept in one time unit, an average student in three time units, and a slower student may get it only after spending 10 time units.

A second point develops from the first. An approximation of the standard deviation of the time estimates can be made by using the following formula:

$$\sigma = \frac{b - a}{6}$$

The standard deviation may be regarded as the uncertainty factor. Low values of standard deviation indicate little variability between optimistic time and pessimistic time estimates. On the other hand high standard deviation values indicate a great deal of uncertainty. The curriculum planner may be well advised to examine the events carefully to see if they can be

restructured so that the uncertainty factor is reduced.

Activity times must be completed for each activity line on the network. Caution must be exercised when timing several activity lines fanning out from a single event. Even though the event may constrain several events, it will be taught only once. Unless new activity is introduced on each activity line, each activity line except the first one, will have zero time associated with it.

Once each time estimate has been prepared the total times can be added together to derive the overall time estimate for the network. The network time is the sum of all t_e's. There is a 0.5 probability of completing the program within the time period indicated by the sum of the activity times ($\sum t_e$). Should the summed activity time depart from the allocated time by an appreciable amount, the network should be examined with an eye to making revisions which will improve the time required for completion. Once the networks are timed, the next step is network interfacing and integration.

<u>Network interfacing and integration</u>. As a prelude to a meeting with others who are developing networks, each network designer should first identify those events constrained by activities on other networks. As an example: if development of a science concept constrains an event in the automotive program, then the designer of the automotive curriculum should specify the interface. Secondly, the designers should specify the sequential prerequisites for starting the network.

Once the interfaces have been identified the several particpants meet and attempt to interconnect the networks. Since the networks have already been timed it is possible to identify the interface within a time frame. If the situation arises where interfaces are not readily achieved, then it is imperative that alternate solutions are worked out.

Interfacing and integration is completed when the participants agree on the concurrent and sequential constraints placed on their networks by other networks.

Network validation. Network validation, though treated separately here, may be considered as the last stage of network integration. The purpose of validation is to insure that, through interfacing, the program does not extend beyond the specified time limits. Properly validated, a program reflects both concurrent and sequential integration, and yet remains within the specified time parameters. Validated networks become the final plan to be used to meet the assigned objective. Each time a network is modified the validation process must be repeated to insure that the total curriculum retains integrity.

Network summarization. Network summarization is a process of developing a simplified network to reveal to institutional and societal planners the implementative action being taken at the instructional level.

Summarization begins by identifying key events in the networks. These key events can be the beginning and ending of sequences within the network, events constrained by many other

events, events constraining many other events, and events which interface with other events. These selected events are then incorporated into a simplified network. Activity times between events on the summary network are the cumulative totals of all activity times between the two events in the instructional network. Events on the summary networks carry the same identification numbers as their counterparts on the detailed network.

Summary

Curriculum planners have in the past had many means of selecting curricular content to meet specific aims and objectives. Curricular organization which reflected intracurricular relationships, and more important intercurricular relationships, has been achieved, more often than not, through teacher insight. It has been shown that PERT technology can fill this gap by providing the means of structuring a curriculum comprised of virtually any number of courses.

Equally as important as a valid network representing the entire scope of a program is the ability to summarize the program for senior levels of school management.

Finally, once developed, a curriculum constructed by means of PERT technology is not rigid, but can undergo continuous changes yet always reflect the significance of the change to all levels of planning.

CHAPTER V

IMPLEMENTATION OF THE NETWORK-BASED CURRICULUM

Overview

Once the curriculum has been structured there are at least four methods of implementation in the classroom. First, there is the traditional departmentalized approach. The instructor uses the curriculum plan as a guide while presenting material to groups of students largely through lectures and demonstrations. Class progress is in unison and there is little attempt made to accommodate individual differences. Secondly, there is the method referred to as cooperative or team teaching. The students progress in groups but several instructors share the responsibility of presenting the planned curriculum. The major attraction of this approach is in the fact that the teachers plan the total program and in presenting it attend to the interrelationships of the segments. Thirdly, there is individual instruction. Students progress at their own pace and in areas that satisfy their needs. Some of the material that appears in this chapter was developed as part of a pilot individualized science program offered in a vocational high school. The final method of implementation is individually prescribed instruction.

This chapter examines how each of these implementation methods may be achieved in classrooms by adhering to a

network-based curriculum. Prior to discussions of each method, the common prerequisites of all methods will be detailed.

Preliminary Planning

Previous chapters have detailed the procedures whereby the curriculum content has been selected and organized, interfaces have been established, and integration and validation has occurred for all networks in a specified program. Prior to embarking on any method of implementation the instructor has a viable network to follow which reflects curricular objectives for a course, or sequence of courses.

The first step toward any method of implementation is to carefully record the objective to be met in each event. Though this may have been accomplished, in part or total, during the network construction, it must be recorded on a form similar to the Lesson Development Form, Figure 15, together with other data such as event and network numbers and activity times. The form serves as the instructor's worksheet and must be prepared for each event on the network. The completed forms may be filed in numerical sequence under the network designation codes. Access to the filed forms is by means of event numbers displayed on the curriculum network, a document that should always be near at hand.

The second step is to delineate the content scope to be covered as a prerequisite to meeting the stated objective of each event. This content selection will vary from instructor to instructor and is, for that reason, not specified in the

Topic____________________

Number of lessons________________

Event No.__________

Network No.________

OBJECTIVE

CONTENT

Scope	Audiovisuals	References

INTERFACES

Within the network	Between networks

REMARKS

Figure 15. Lesson Development Form.

curriculum network. The scope, and other data such as audiovisual aides, references, interface data, and remarks, are documented on the Lesson Development Form.

Before selecting the most appropriate method of instruction the instructor has a curriculum network and a set of worksheets describing precisely what is to be achieved, together with a list of materials available for accomplishing each event.

Implementation of the Network-Based Curriculum

Traditional departmentalized approach. The instructor using the network as a guide to sequence and direction provides the instruction specified by the appropriate Lesson Development Form which, in this case, serves as a lesson plan. When the class meets the specified behavioral objectives, it moves under the guidance of the instructor to the next unconstrained event. The network serves as a reminder of material covered and material to be covered, as well as an overall indication of progress. By recording the actual time to accomplish the activity adjacent to the estimated time, t_e, the instructor can gauge progress against the plan.

Team teaching approach. The team teaching approach is essentially the same as that of the traditional approach with the exception that several teachers are each concerned with different segments of a mutually developed and validated network. Periodic progress reviews alert others to potential delays in meeting interfaces and allows time for alternative

strategies to be developed.

Individual instruction approach. This approach to curriculum implementation is extremely useful in dealing with individual students and will be developed in considerable detail. The first consideration to be taken in developing this approach is to survey the basic criteria for an individual instruction program in an effort to establish the nature of the approach most likely to achieve success.

Implied in the term individual instruction is the idea that a student can work at his own rate of speed on material selected to meet his needs and interests. Taba's (1962, p. 286) concept of educational needs is used here--the disparity between what a student should have and what he has. Progress at one's own rate of speed is of primary concern at this stage of development.

The first problem begins to crystalize at this point. If x number of students begin at the same point in a program and at a specific time, at any later increment of time they will be found at x number of positions along the achievement continuum. Obviously, the teacher can no longer be the focal point of learning: the students must, for the most part, interact with the teacher through an intervening medium.

Similarly, the second problem is quickly isolated. Some students will have mastered more material and in different areas than others, at any point in time. Since it is foolhardy to expect students to follow identical programs, they

must have access to flexible programs.

Clearly then, any approach to individualized instruction must enable the teachers and students to interact through some medium as the students follow flexible programs, yet the approach must remain administratively feasible.

Since this method of implementation is meant to be feasible at the classroom level, it must start with those things available to every teacher. The first stage in preparing for a program of individualized instruction is to extract from the program curriculum network those objectives centering around topical areas. This is tantamount to identification of curricular modules conceptualized by Goodlad, O'Toole, and Tyler (1966, p. 14). Examples of several curriculum modules which were developed as part of the initial investigation into individualized instruction in a vocational high school are shown in Figures 16-18. The modules are subsumed under the course summary network, Figure 19.

The detailed networks of the sort shown in Figures 16-18 are intended to serve several vital purposes.

1. The networks provide at least four features of particular value to the students: (a) they serve as "advance organizers" of material to be presented (Ausabel 1965, p. 111) and (b) they serve as progress records. Completion dates for each objective can be recorded thereby showing each student the progress made. Goals are more meaningful since they can be achieved in a short period of time rather than over longer intervals. They serve as locators of randomly stored printed

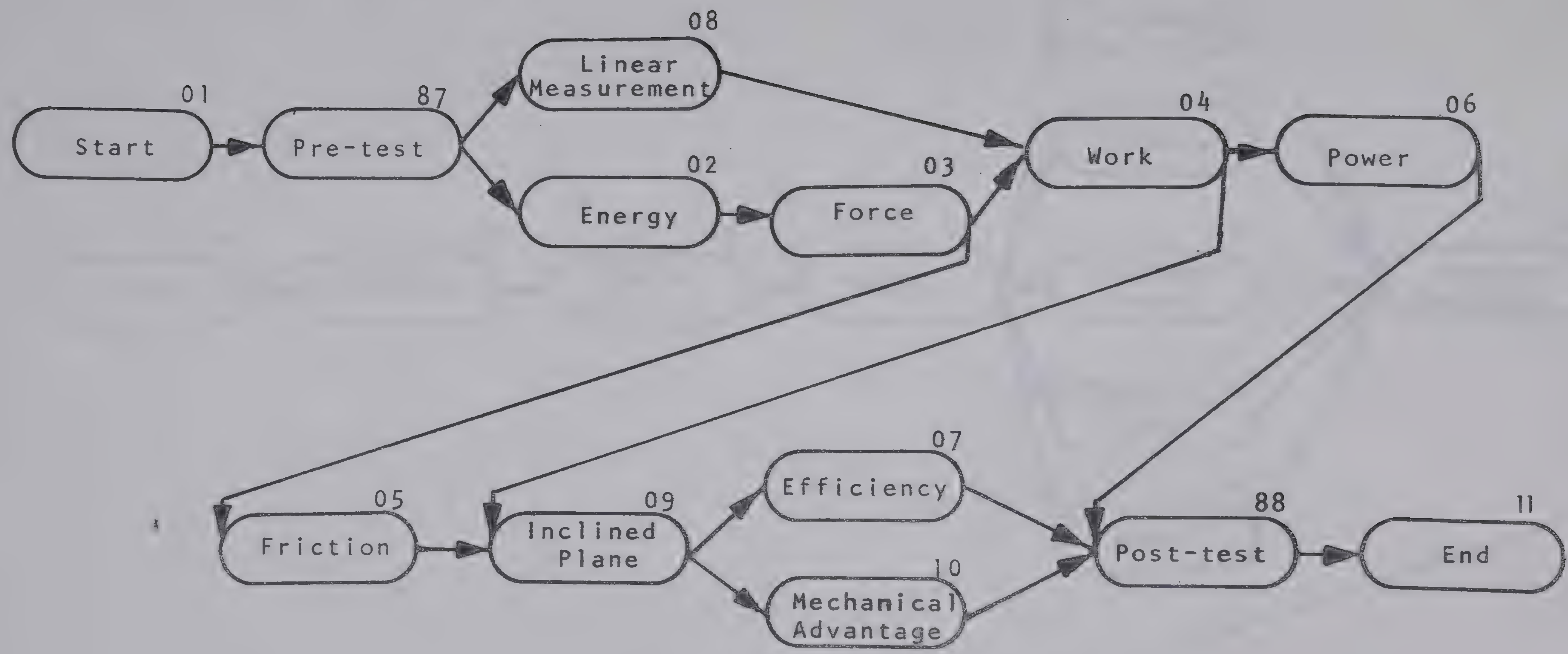

Figure 16. Force, work and power network.

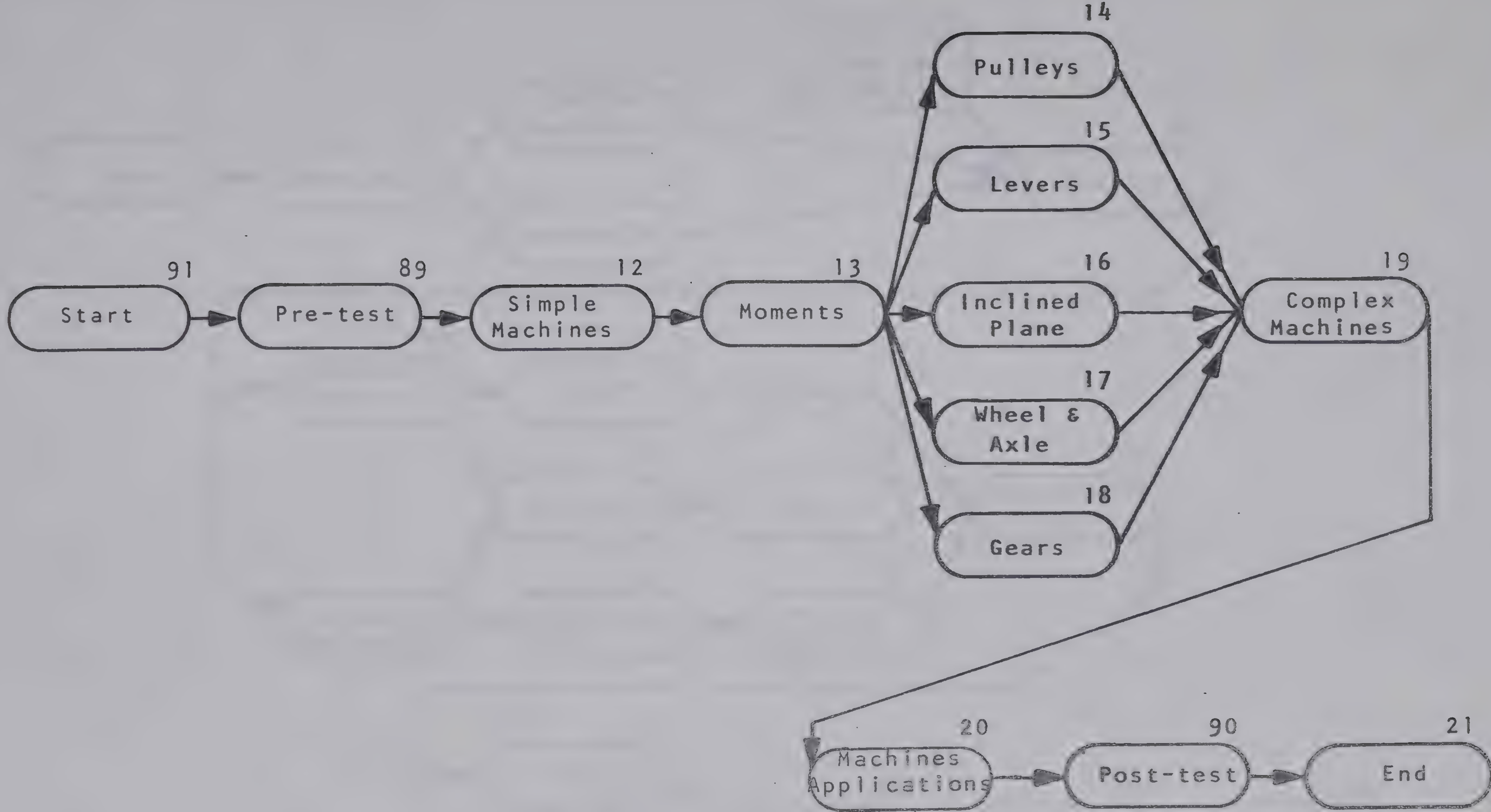

Figure 17. Simple machines network.

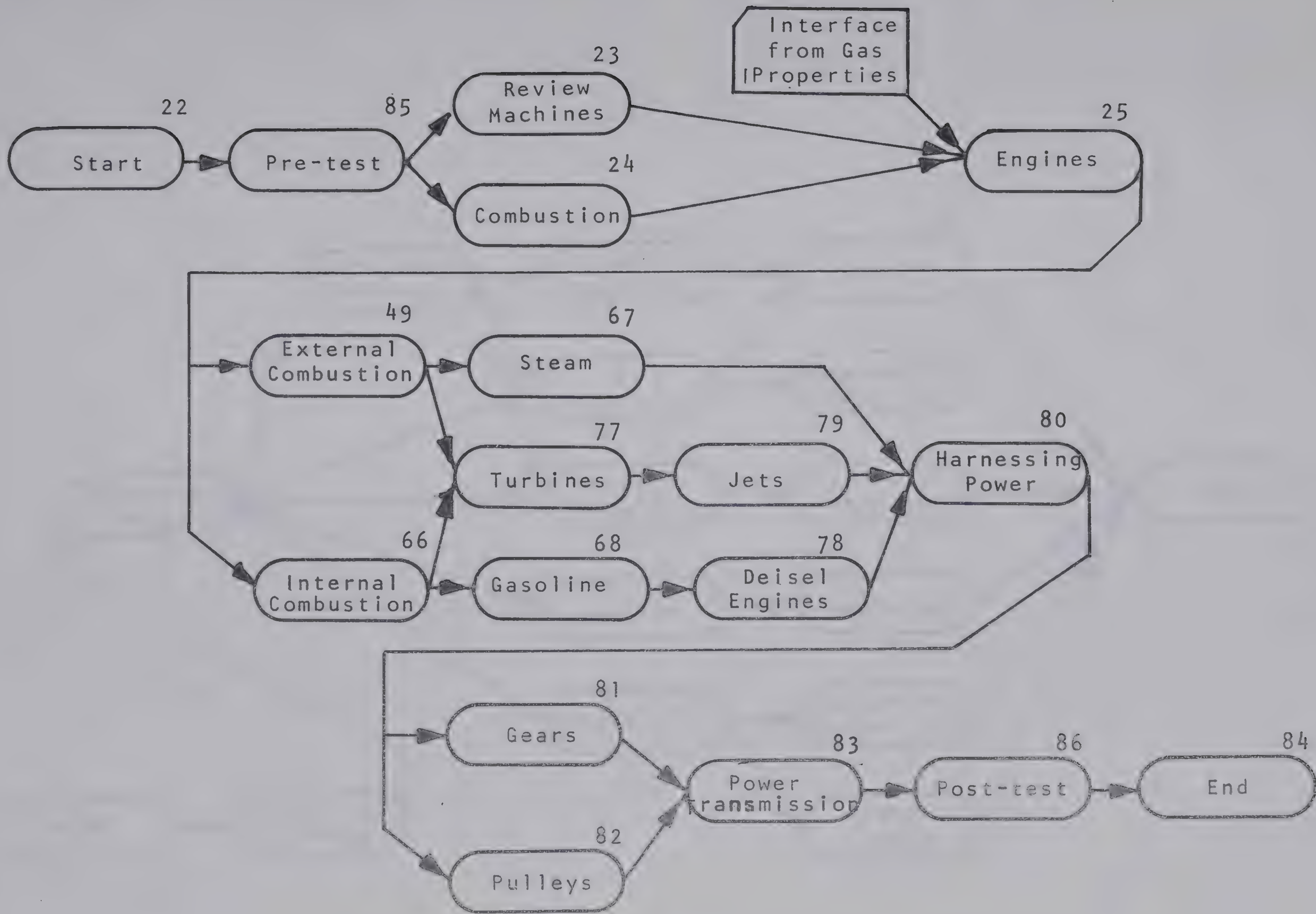

Figure 18. Engines and complex machines network.

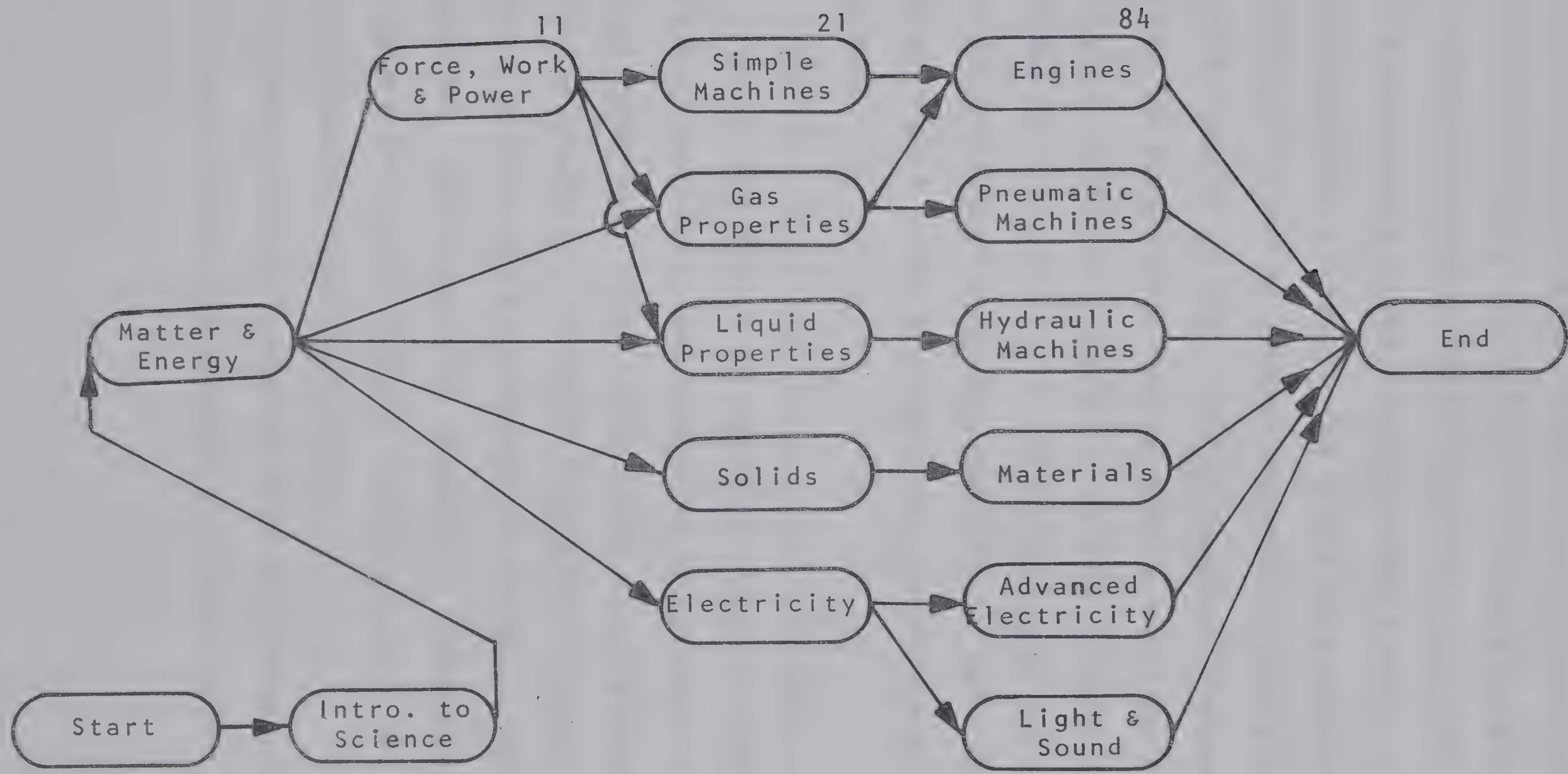

Figure 19. Two-year program of science (Physics).

materials and audiovisual aids. Each event designator is used to identify all material relating to that event (objective). They serve to allow students flexibility in selecting the units of study most closely allied to their activities in other classrooms, particularly their classes in vocational areas. As students in the exploratory year of the cited vocational programs spent periods in each of several vocational areas they chose appropriate science courses. As an example--a student may have selected to study concurrently Simple Machines and Automotives, Liquids and Pipe Trades, or Solids or Materials and Industrial Metals. Vocational teachers serve as effective guidance counsellors by assisting the students in selecting the appropriate study topics to be pursued concurrently with vocational classes.

2. The networks serve the teacher in three major ways. They provide a convenient device on which to record student progress; pre-test, post-test, and objective completion dates, all serve to show progress. They reflect the total program, with all of the interrelationships for planning of lesson materials and they provide an easy method of adding, changing, or deleting material. The impact of changes is immediately reflected throughout the total program because all of the interrelationships can be seen graphically.

3. The cited networks, together with the summary network, Figure 19, are of use to the administrative staff. They

are able to review the progress made by each student and they are able to review program development progress. They can judge the general merit of the program without trying to relate one lesson plan to another lesson plan, as is the case in traditional approaches. The latter assumes, of course, that meaningful lesson plans are generally available. They allow planning for resource expenditures since each activity line represents resource consumption. Networks, by enabling an individualized approach to instruction, reduce the amount of equipment required to accomplish stated goals. Where traditional instructional methods require enough equipment for students to simultaneously undertake activities, the individualized approach needs only one set of equipment, since students require it at different times during the course of the program.

Thus far the implementation of individualized instruction has included development of a curriculum network, extraction of curriculum modules, and preparation of lesson outlines that can serve as guides for subsequent material preparation.

The final step moves from the lesson plan outline to the structuring of a self-teaching lesson for student use. These lessons must be carefully constructed, because in implementation they become an instructor surrogate. In some instances they may resemble home-study lessons. In other cases they may consist of audio or video recordings,

films, programmed instruction, pictorially programmed instruction, computer-assisted instruction, or countless other methods. The lessons can be designed to either develop the stated objective for the specific units with evaluation to be carried out independently, or to use curriculum embedded tests whereby students assess their own progress. In this method of implementation the teacher, during class time, is freed to deal with individual problems.

Individually prescribed instruction. Implementation of individually prescribed instruction (IPI) is contingent upon development of a diagnostic instrument capable of paralleling the program curriculum network. Once achieved the students are screened and assigned individual program formats that begins at the point where understanding of the curriculum content begins to diminish. The remainder of the program implementation is the same as that of individualized instruction.

Instructional Material Control

The importance of network and event designation becomes apparent at this point. All related materials such as films, tapes, slides, CAI programs and so forth are all coded with the appropriate event code. As an example "77" would provide access to all of the media related to Turbines, Figure 16.

Within a classroom pigeon-hole storage spaces are adequate for storing the material which is filed in numerical sequence--random access being gained through network and event

identifications. In larger systems a computer may be used for data retrieval, but the coding system is still available in network and event identifications.

Student Programming

The student's programs can be assembled to serve each individual. As already mentioned, other teachers can be instrumental in assisting students with choices of curriculum modules. No real constraints are placed on programming. The student undertakes any unconstrained objectives that are of interest to him or which he, or his counsellor, feel will benefit him most.

Scheduling

Within the area covered by the master curriculum network, the student can proceed at will. In the ideal sense he simply completes an objective and proceeds to the next unconstrained objective. If the curriculum coverage area is only one or two courses, then the student is constrained by other courses but is still free to pursue the objectives in a network at will. This can be done in regular classes, during free school time, or at home.

Summary

The network-based curriculum approach is practical whether implementation is through traditional means, team teaching or individualized instruction. In addition to being a valuable organizer of objectives to be met by the students, it is administratively attractive. Going to the extreme of a totally non-graded school where every student pursued an

individualized curriculum, this program remains attractive. The administrative details do not become insurmountable. Student programming is simplified by the availability of curriculum modules which can be built into sequences of educational experience for the students. Finally, instructional material control is handled by the approach with the network objective identifiers serving as a random access device.

CHAPTER VI

EVALUATION OF THE NETWORK-BASED CURRICULUM

Overview

It has been recommended by Cook (1966), Grobman (1968), and Werner (1968) that PERT be considered when attempting to resolve educational problems. Since the concept of program evaluation is embodied in PERT, it will be examined as a device capable of facilitating curriculum evaluation. Evaluation is the last stage in the model of curriculum development (Figure 4) but the first step toward curriculum revitalization. Without revitalization the curriculum quickly becomes obsolete.

A review of related research is undertaken in the first part of the chapter to isolate key factors involved in curriculum evaluation. Following the development of a model based on selected factors, the PERT approach to curriculum development is subjected to an evaluation of its capability of meeting the specified evaluative criteria.

Related Research

The concept of curriculum evaluation embodies two significant aspects--evaluation of the curriculum program and evaluation of those for whom the curriculum was designed to serve. While the latter concept may serve to sort and screen candidates into various segments of society, the former insures that the screened students have had an opportunity to gain the

attributes deemed necessary by society. There is no benefit to either students or society if the students meet all the evaluative criteria prescribed by a curriculum when the curriculum is not aimed at serving social needs.

It is the position of this thesis that one of the most important aspects of a curriculum development approach lies in its ability to clearly show how the curriculum meets the stated aims and objectives of society. Only after the curriculum meets its intended aims and objectives is it beneficial to inquire whether students meet the criterion behavior specified by the curriculum. This does not preclude the fact that an element of student evaluation is needed in shaping the aims and objectives, or in reshaping them.

Two features of PERT, already demonstrated, enhance its applicability in curriculum development. First, the networks can be integrated into larger networks representing the activities of a team of specialists. This implies, as demonstrated in chapter 5, that the curriculum can be centered around a host of organizational schemes, even in schools that are highly departmentalized. Secondly, since the networks can be summarized, each planning level sees the structure required to implement the aims and objectives appropriate to that particular level. As the networks are subjected to review at each level, the key events highlight problems.

Evaluation of a PERT program begins by evaluation of each event. Curriculum theorists, notably Mager (1962) and

Popham, Eisner, Sullivan, and Tyler (1969) espouse the position that educational objectives should be set forth as measurable behavioral objectives. This is important to a good program because evaluation begins by stating objectives in terms of anticipated outcomes. PERT events, the constituent parts of PERT networks, are sufficiently congruent to educational objectives when expressed in behavioral terms so that PERT methodology retains its integrity when applied to curriculum development. With the curriculum content set forth in behavioral terms, PERT facilitates establishment of sequence, continuity, and integration. But what of evaluation?

Frymier (1969, p. 36) is of the opinion that curriculum evaluation is practically non-existent, though most of the curriculum theorists stress its importance. Guba (1969, pp. 29-38) concurs with Frymier's position and suggests that the lack of suitable curriculum evaluation stems from lack of comprehension of the evaluative process and mistrust of the results.

Elsewhere in the literature are numerous approaches to curriculum evaluation. Among them is the approach of Stake (1968, pp. 336-346) which presents a matrix that may be superimposed over the curriculum. When applied at the societal or institutional level, the matrix offers an excellent format for categorizing and organizing relevant data. The effectiveness of a specific program may be evaluated after first collecting data to fill each of the cells of the model (Stake 1968, p. 339).

Curriculum development involves decision-making at all

levels, including the classroom. The manner in which decision-making is executed influences the quality of the program and hence is a factor in evaluation. Stake's model, when applied to the many objectives that must be achieved in the classroom loses its effectiveness because it becomes cumbersome. Too much data is required.

Saylor and Alexander (1966, pp. 254-256) offer a check-list of evaluative criteria to be applied to school programs. A comparable list is offered by Verduin (1967, pp. 129-137).

The three cited approaches have a common characteristic. They all remove evaluation of the curriculum out of the context of curriculum development and treat it as a separate process. Guba's (1969, p. 38) proposal for a technology of evaluation would be one way of overcoming this problem.

<u>A Curriculum Evaluation Model</u>

Grobman (1968, pp. 110-112) synthesizes contemporary thought on curriculum evaluation and offers a checklist of items relevant to evaluation of a curriculum program. Some of the key aspects have been selected for their centrality to curriculum evaluation and integrated into a model of curriculum evaluation.

<u>Decisions</u> - Who makes the decisions and how are they made?

<u>Communications</u> - What are the strategies for communicating the curriculum decisions to the involved population segments?

<u>Facilities</u> - Are the facilities available to implement the change? How does one know what facilities are needed?

<u>In-Service</u> - How can teachers become involved in the program?

<u>Student differences</u> - What are the provisions for student differences?

<u>Effectiveness</u> - What will the program do to the students?

<u>Mobility</u> - What happens to students entering or leaving the school system?

<u>Teachers</u> - What must be their characteristics and what are the demands placed on them?

Uniting Goodlad's (1968, p. 221) concept of planning levels with the evaluative dimensions selected from those suggested by Grobman provides an evaluation matrix, Figure 20. This matrix exemplifies some of the key qualities that any approach to curriculum development should embody if it is to be effective.

<u>Decisions</u>. PERT planning begins with the formulation of an objective at the apex of the organizational structure, the societal level shown in Figure 6. Though the societal level is remote from the implementation level in the classroom, it is incumbent upon the societal planners to specify how they propose to judge the products and processes at the instructional level.

As outlined in Chapter 4, the global objectives proceed

	Planning levels		
	Societal	Institutional	Instructional
Decisions			
Communications			
Facilities			
In-service			
Student differences			
Effectiveness			
Mobility			
Teachers			

Figure 20. A curriculum evaluation matrix.

downward through several levels, each level adding information by carefully specifying objectives for the subordinate levels. It is these initial steps--the statements of aims and objectives--that are most difficult since they specify the picture to be reflected at some future point in time (Schaefer 1969, p. 22). O'Kelley (1969, p. 31) and Doll (1964, p. 146) stress that the societal planners must carefully delineate in each of the objectives how progress is to be judged along the way.

Utilizing PERT entails preparation of statements of objectives at each level of planning with network construction occurring at the instructional level and reflecting back to the societal level in summary form. Properly constructed and summarized, each level is provided with a graphic portrayal of how their objectives are being met. The impact of revision at the lowest level is carried through to the higher levels in summarized networks to an extent compatible with objectives at each level.

Communications. As reflected in Figure 6, communication downward is in terms of aims and objectives while upward the communication consists primarily of graphic representations of strategies for attaining the aims and objectives. Also functioning is feedback of evaluative criteria in terms of exceptions to planned progress. Feedback may precipitate either amendment or alteration of the curriculum plan.

PERT offers a further advantage in that it allows horizontal communications at any level, and most effectively where

networks integrate with other networks to provide effective team action.

Of equal interest and concern at the instructional level is the adaptability of PERT in conveying the structure of the curriculum to the students. Properly constructed the networks should reflect a viable approach to the structure of knowledge within a discipline or field of disciplines which is somewhat difficult for students to perceive even at advanced levels of education. Networks presented to students may be regarded as permanently available "advance organizers" suggested by Ausabel (1965, p. 111).

Facilities. Handmaiden to PERT is PERT/COST, a means of planning for the allocation of resources. Like PERT it reflects a realistic picture to each of the several levels of planning.

It may well occur that while setting forth objectives at one of the levels, the objectives might entail modification, addition, or deletion of facilities. PERT and PERT/COST are extremely useful in planning in this regard. This point will not be elaborated at this time since it is outside the domain of this thesis.

In-service. In-service education may be broadly defined as on-the-job education which serves to maintain or increase competency. Just as networks serve as advance organizers for students, so may they serve the same function for in-coming teachers and planners at any level of activity. Regardless of the entry level, and appropriate network reveals both the plan

and progress made towards its achievements.

Student differences. Student differences become real rather than apparent in the classroom. Many forms of grouping have been attempted in order to optimize the learning environment for children. Few have had the degree of success hoped for with the possible exception of individually prescribed instruction (Alpren, 1967, pp. 16-17).

The steps in developing individually prescribed programs for students are; develop a structured curriculum, assess student achievement with respect to the curriculum, and implement instruction where gaps between the two begin to occur (Lindall and Cox 1969, pp. 156-188).

This may be where PERT can make its greatest contribution to education--by providing a structure of learning objectives both amenable to diagnostic testing and readily available to serve as a roadmap as students advance along the paths of learning.

Goodlad, O'Toole, and Tyler (1966, p. 14) suggest that curriculum modules, which can be manipulated by computer, are needed if the curriculum is to be effective in the future. As demonstrated in Chapter 5, curriculum modules can be extracted from the larger course and program networks. Industrial programs already exist for certain manipulations of PERT events and networks. Adaptation, or paraphrasing, of the programs may provide program construction, diagnostics, data retrieval, data processing, and a host of other activities, to an extent which

avails all students of individually prescribed programs.

Effectiveness. Brown (1954, pp. 281-282) and Goodlad and Anderson (1959, pp. 143-168) concur that unsatisfactory individual interaction with a task often results in undue emotional stress if the task does not embody perceptible characteristics of the whole. When production-line workers in industry experience job dissatisfaction, morale lowers as well as productivity. Clearly there is a relationship among the three characteristics. One way of regarding the characteristics is shown in Figure 21.

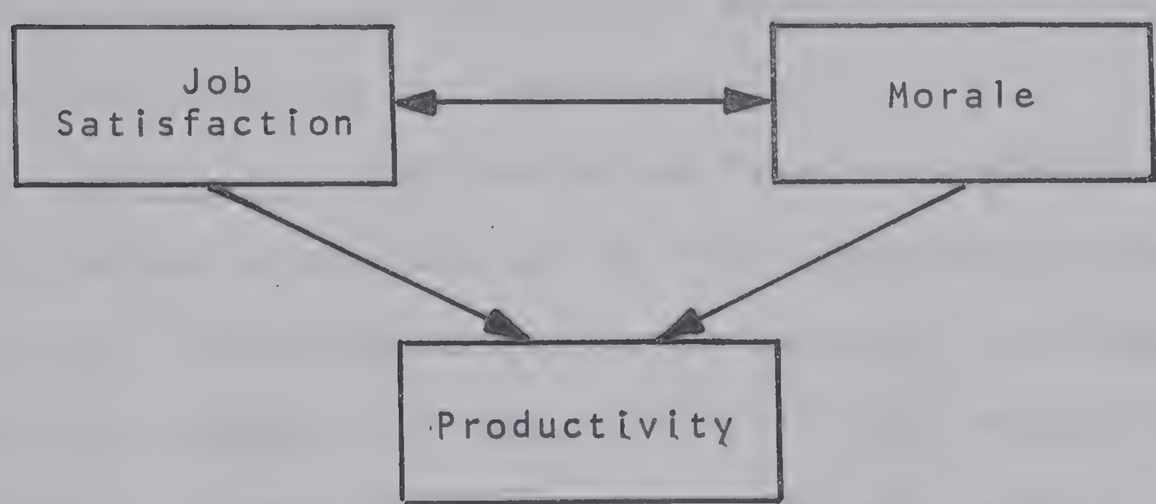

Figure 21. The relationships among job satisfaction, morale and productivity.

Job satisfaction and morale influence each other with either one having an effect on productivity. In the context of curriculum development, student productivity may be expected to be high when job satisfaction and morale are high. The latter aspects are influenced extensively by relationships of specific tasks to the whole. Curricula structured in the form of networks is one step toward increasing job satisfaction by

identifying relatedness of the parts to the whole.

One of the stated aims of this thesis was to develop a viable approach to curriculum development for vocational education programs. Vocational education was defined as including both skill and attitude development.

The proposed approach is effective in focusing on skill development. Attitudes are more difficult to deal with but as Conner and Ellena (1967, p. 306) point out, in team teaching where all instruction focuses on commonalities and relationships, attitudes can be taught. Carefully structured programs centering around objectives from Cell 1 of Figure 12 pave the way for introduction of objectives from Cell 11, objectives intended but unmeasurable.

Mobility. Carried to an ideal end--instantly computerized programs prescribed on an individual basis from a data file of all possible interrelated concepts and based on exhaustive diagnostics--mobility will pose no problems for students. Students would not abandon program but simply change computer terminal locations. Moves from proposed systems to the traditional systems could have no greater disadvantages than presently encountered. Perhaps there would be fewer disadvantages because having been exposed to an optimal system the student would have a well founded structure of experience upon which to build.

Teachers. Adoption of the proposed approach to curriculum development relieves teachers of their traditional role as dispensers of knowledge and enables them to become facilitators

and organizers of more effective educational programs.

Summary

PERT offers an approach to curriculum development which meets the selected evaluation criteria postulated by Grobman and at the levels specified by Goodlad. As opposed to externally structured curriculum evaluation plans, the PERT approach has an inherent means of evaluation. Not only may the specific learning objectives each be evaluated but the sum of all of the specific objectives--the program--is evaluated concurrently.

CHAPTER VII

MANAGEMENT PLAN FOR IMPLEMENTING A NETWORK-BASED CURRICULUM DEVELOPMENT PROGRAM

Development of a network-based curriculum for a course in a classroom, a program within a school, or a set of programs in a school system is most easily achieved after appropriate planning. While every organization will ultimately adopt a plan particularly suited to its unique needs, the management plan outlined in this chapter may serve as a basic plan amenable to modification. Not only is it important to have a management plan to facilitate network-based curriculum development, it is also important to understand the organizational climate best suited to PERT planning.

It must be recognized that within the network-based management approach no single discipline has priority over any other while planning integrated programs. As the initial philosophical aims and objectives are translated into networks, there may appear to be a loss or diminution of scope in certain disciplines over traditional approaches accompanied by accentuation of other disciplines. The content scope contained in the completed networks represents the most efficient means of attaining the stated ends.

A second factor influencing network-based curriculum development is the organizational framework. Ideally the

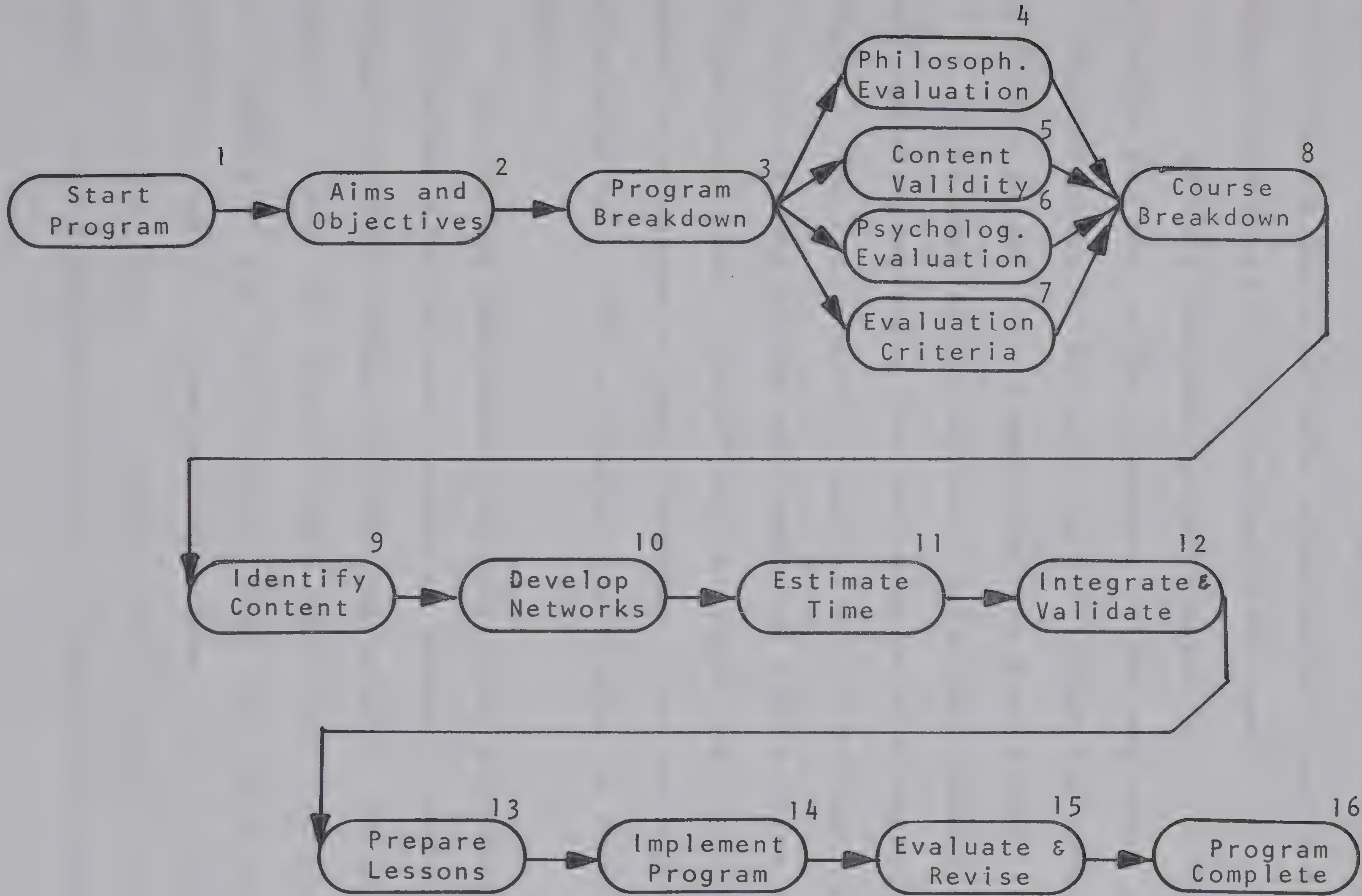

Figure 22. Management plan for implementing a network-based curriculum development program.

organization should have a clearly defined structure paralleling the levels indicated in Figure 6. If all levels do not participate in planning then those levels participating should lie adjacent to each other in the organizational hierarchy. Failure to provide a suitable organization results in poorly defined objectives at the instructional level.

In certain instances network-based curriculum development may begin and end in the classroom. This may occur in the form of reconstruction of an existing curriculum (as embodied in a curriculum guide) into a more flexible educational tool.

To be most effective, curriculum development at each level should come under the jurisdiction of a curriculum coordinator. The coordinator's task is one of motivating interest in curricular activities and resolving difficulties arising out of interface areas. The effectiveness of the coordinator as a leader is increased by good planning. A suitable plan which may be adopted by the curriculum coordinator is shown in Figure 22.

Curriculum development activities at any level begins with the decision to start a program (event 1) and is closely followed by establishment of the program aims and objectives (event 2). Next the superordinate curriculum coordinator meets with members of the institutional level for the purpose of translating societal aims and objectives into a Program Breakdown Structure (event 3). Meeting the criteria of event 3 results in program specifications in terms of end objectives

and time allocations.

Four evaluations (events 4-7) of the objectives contained in the Program Breakdown Structure should be undertaken. The philosophical evaluation insures that the program is in keeping with the needs of society and the roles of the institutions involved. Program priorities are established. The evaluation of content validity insures that the selected objectives are appropriate in meeting societal aims and objectives. Verification of the validity of objectives during curriculum development reduces the risk of program failure. A psychological evaluation of the objectives insures congruency with the cognitive, affective, and psychomotor abilities of the students involved. Finally, the evaluation criteria by which the program is to be judged must be extracted from the objectives. Throughout this study it has been emphasized that the key to evaluation must be inherent in the statement of educational objectives.

Operating within clearly defined parameters institutional planners, together with instructional level planners, prepare a Course Breakdown Structure (event 8). The Course Breakdown Structure is similar to the Program Breakdown Structure except that it contains more detailed objectives.

Instructional level planners working from the Course Breakdown Structure, identify curriculum content (event 9) and organize it into networks (event 10). The methodology is described in Chapter IV. Once structured the networks and events must be identified and activity times estimated (event 11).

Following event 11, group meetings facilitate establishment of interfaces, network integration, and validation (event 12). With event 12 completed the network-based curriculum may be implemented in any of several ways in the classroom. Some possible variations are discussed in Chapter V.

The remaining events in Figure 22 serve to facilitate program implementation. Each department may find that they are involved with several networks. As an example, a different science program may be offered to students in each different vocational program. While each science course differs from the others, there will be some degree of content commonality. Since this is the case each department should screen all of their networks and prepare a cross-index of all events appearing in two or more networks. This step eliminates redundancy in lesson development. Finally, to complete event 13, Lesson Development Forms similar to those shown in Figure 15 must be prepared. This step can be carried out by individual teachers but the effectiveness of the program is increased if all of the teachers in a department develop the plans cooperatively. The cooperative approach offers several advantages.

1. All materials may be centrally stored and accessed through use of appropriate network and event identification numbers.

2. All teachers utilize a fund of knowledge and experience as they prepare lesson material for use in their classes.

3. By eliminating the task of continual lesson planning the teachers are free to concentrate on improving the lessons

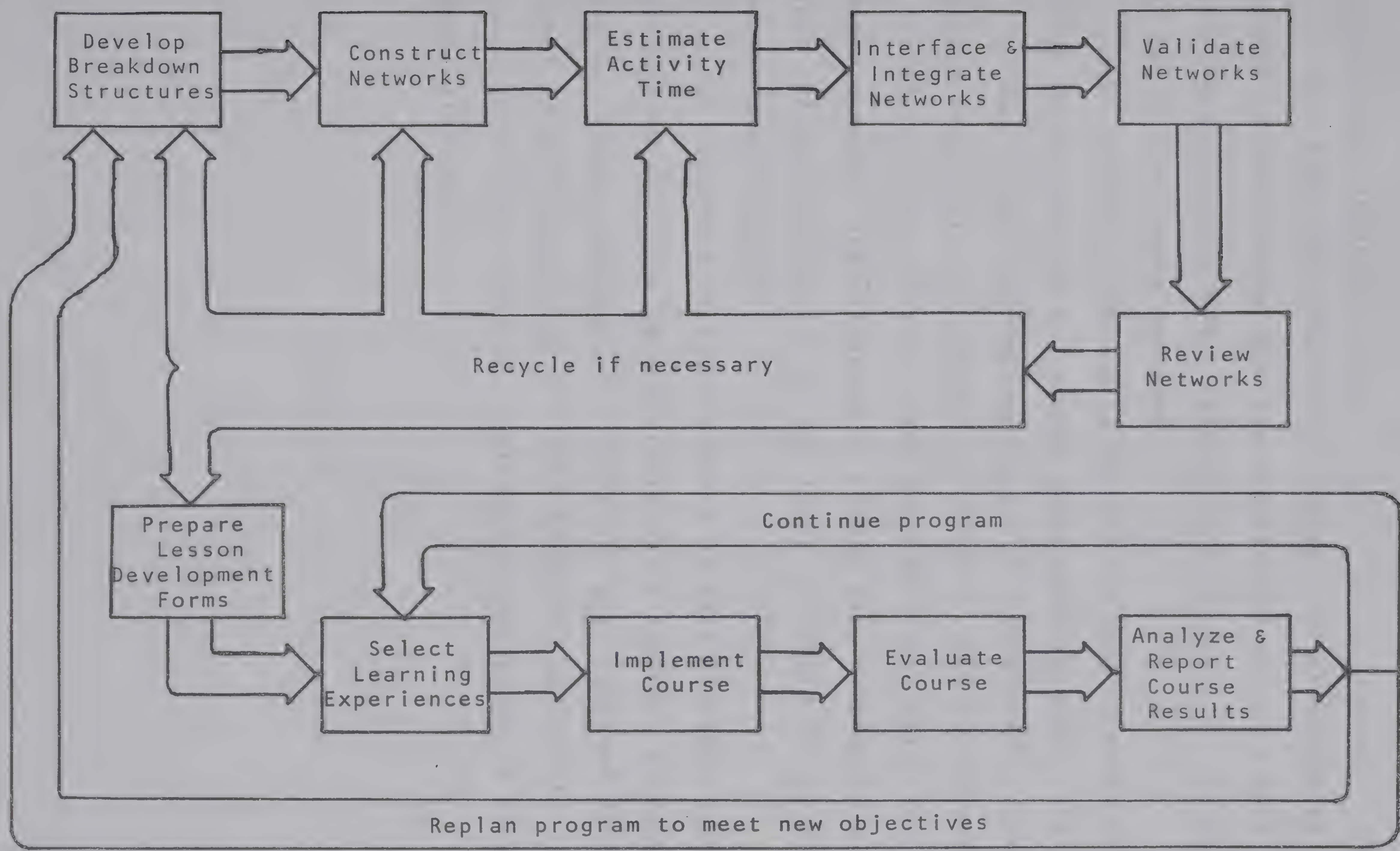

Figure 23. Dynamics of the network-based curriculum development program.

and methods of implementation.

4. Substitute teachers, interns, and aides can be oriented to the program in a few minutes and are then able to locate material and present lessons both relevant to the program and in the proper sequence.

5. Lessons continually improve through constant feedback of more effective approaches discovered through practice.

Concurrent with implementation of the program (event 14) feedback data begins to accumulate which is used in the process of evaluation and revision of the program (event 15). The program dynamics are reflected in Figure 23. Program completion (event 16) occurs when all of the loops in Figure 23 are able to function simultaneously.

As suggested at the beginning of this chapter, each organization will develop a characteristic approach to network-based curriculum development. While the plan outlined in this chapter is sufficiently detailed to insure an acceptable standard of quality in most settings, modification can adapt it to more unique situations.

CHAPTER VIII

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FURTHER STUDY

Summary

This thesis stemmed in part from the assumption that problems of industry and education were sufficiently similar to warrant an investigation into the suitability of PERT as a tool in developing vocational education curricula for team teaching and individualized instruction. An examination of the parameters of curriculum development revealed a number of factors which had to be reconciled in an approach to curriculum development. An examination of PERT technology revealed the extent to which it was capable of accommodating these factors. Chapter IV outlined the method of developing a network-based curriculum. Chapter V discussed several methods of implementation including individualized instruction which was subjected to a brief study in the classroom. Chapter VI evaluated the network-based curriculum in terms applicable to any curriculum program. Chapter VII outlined a management plan for a network-based curriculum development program.

The initial findings of this study suggest that the practicality of the network-based approach to curriculum development is defensible. At the outset of this study six research questions were posed. Though the questions were used as

a guide during the study it may be useful to re-examine each question to more precisely determine the extent to which the proposed approach is successful.

Content selection and organization. By adhering to PERT technology for breaking program objectives into many specific objectives and coupling this with any of several curriculum selection techniques, it has been demonstrated that curriculum content can be identified. By stressing the use of behavioral objectives, it was possible to follow the PERT technology to organize content into networks which reflect the structure of knowledge within a discipline or among several disciplines.

Concurrent subject interrelationships. Simply following PERT technology enabled identification of the relationships among concepts and principles found in vocational subjects and related academic subjects. When going beyond a single subject, it was demonstrated that several subject networks may be organized into a larger network simply by identifying the interfaces. Once completely interfaced, instead of a set of subjects offered concurrently, the curriculum consists of one network which enables students to find their way through several subjects, always aware of the subject interrelationships and never losing sight of the terminal goal.

Sequential subject interrelationships. Just as the approach solved problems of concurrent relationships among courses, so may the approach handle sequential subject interrelationships. In effect, successor courses establish the

prerequisite relationships of predecessor courses.

Network-based curricula as facilitators of team teaching. A prerequisite to team teaching is the development of individual networks which are interfaced and integrated into a team network. Once validated the team network can be separated into the constituent networks, thus enabling each teacher to progress independently toward the common team goal. If the curriculum was acceptable in its validated form, and if each teacher adheres to the planned progress, the students will be aware of only one program even though the individual teachers are separated into remote corners of the school.

Network-based curricula as facilitators of individualized instruction. Instead of separating the validated network as occurred in team teaching, the program network is dissected into curriculum modules and the curriculum modules are organized into sequences which constitute individual programs. With each module fitting into the master network, students are able to relate their individual activities to the whole.

Administrative control. Any innovation expected to be successful in the school must be administratively feasible. Organized manually, the proposed approach to curriculum development greatly simplifies the administrative load placed on teachers and administrators when attempts are made at offering individualized instruction. Individualized programs are constructed by appropriately sequencing selected curriculum modules. If the students are freed to follow unconstrained events, scheduling

is facilitated automatically. An open climate in a school would enable students to adhere completely to their individualized network thereby eliminating need for administrative scheduling. The approach to individualized instruction separates mere student attendance from performance when assigning student grades. Instructional material control is simplified. Materials are centrally stored with access gained through use of network event designators.

At some point during the adoption of this approach on a large scale, data processing equipment would be a necessity. The transfer of program control from manual to automatic means would be facilitated by the fact that all of the necessary identification codes for data processing are in use in the manual approach.

Conclusions

By the very nature of the type of study undertaken culmination in an incontestable conclusion is impossible. Several questions were posed at the outset of the study. To some extent each question was answered in the proposed approach. From this one may claim a successful conclusion though some of the successes enjoyed during the initial classroom applications may be partly attributed to an enthusiastic approach by the instructor as well as the students. Only after the approach is tested and tried in a number of different environments can it be said to be successful. Controlled tests to measure the effectiveness of the approach will be difficult since the approach is so different from what most teachers and students

experience in the classroom that the "Hawthorne effect" will be most evident. The most conclusive evaluation of the approach might be expected to come from teachers' own evaluations of their experiences in its application.

Recommendations for Further Study

This thesis does little more than structure a skeletal approach to vocational education curriculum development. Every facet considered can benefit from further study and subsequent modifications to the overall approach, therefore, part of the merit of this study lies in its ability to identify areas of further study.

While the study has been concerned with vocational education at the secondary level, there does not seem to be any valid reason for this limitation. The results of this study and the successes of network planning in industrial applications tend to indicate that programs can be structured with enough scope to extend from kindergarten to post-secondary levels. Though a program of such magnitude may not be desirable, further research is justified in extending the limits of the present study. As an example, another study might pursue ways of integrating Industrial Arts programs more tightly into general education.

A final implication of this study lies in the ability of the network-based programs to facilitate planning. It seems logical that any new program would be more efficiently implemented if the curriculum was constructed in the manner outlined in this study while resources were allocated through

PERT/COST or some other budget planning system. As implied in Chapter V, equipment costs of an individualized program over a traditional departmentalized approach to science were reduced significantly by elimination of the equipment redundancies required by simultaneous student usage. Research into comparative costs of different curriculum implementation methods, team teaching versus individualized instruction as an example, could effectively lead to lowered educational expenditures.

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